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A SEED, AND WHAT IT CONTAINS.

By J. Pentland Smith, M.A., B.Sc., &c., *Lecturer on Botany, &c., Horticultural College, Swanley.*

A SEED has from time immemorial been taken as the symbol of reproductive power. To explain adequately what are the significations of its different parts, we must first occupy ourselves with a preliminary developmental sketch, and will commence with a description of the method of reproduction of *Aspidium filix mas*, the Male Shield Fern, one of that large group of plants called Vascular Cryptogams. Its life-history has previously been discussed in this Magazine. At present we will only touch on those parts of its structure which immediately concern us.

Brown patches may at times be noticed on the backs of its leaves. These are collections of spore-bearing sacs, or sporangia, that are covered over by a growth of the leaf termed the indusium (Fig. I. *a*.). The contained spores are all alike. They are minute single-celled bodies filled with protoplasm and nourishing material. The sporangia rupture when ripe, and the spores fall to the ground. There they germinate if the conditions are favourable, and the product of germination is a small green plate of tissue, about one-sixteenth of an inch in length and breadth, and shaped as seen in the diagram (Fig. I. *b*.). It is called the prothallus. On its under surface are two kinds of organs, which are of great importance in the life-history of this fern. These are the archegonia (Fig. I. *b*., *arch*., and *d*.), or female organs, and the antheridia, or male organs (Fig. I. *b*., *an*., and *c*.). The archegonia are flask-shaped. The base of the flask, which is embedded in the prothallus, contains an egg or *ovum*, the female reproductive cell. The antheridia are globular in form. Each one contains numerous lively specks of protoplasm (πρωτος first, and πλασμα form, the living part of the plant-cell, by whose activity the plant is built up), which move about with great agility when the antheridia burst. They then make their way (if moisture be present) to the neck of the archegonium; one of them enters it, and pierces the ovum. Thus impregnation is effected.*

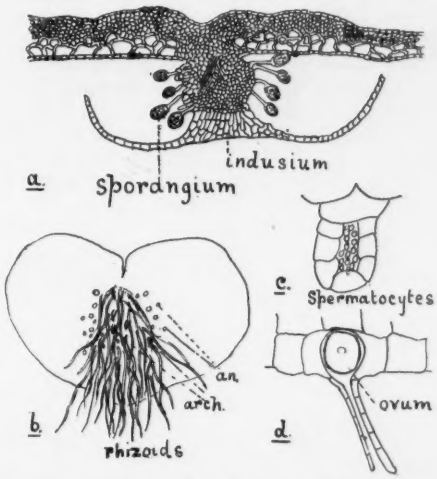

Fig. I.—*a*. Transverse section of leaf of a Fern (*Aspidium filix mas*), showing sporangia. *b*. Under surface of prothallus; *arch*., archegonia; *an*., antheridia. *c*. Longitudinal section of antheridium (much magnified). *d*. Ditto of archegonium.

The result of fertilization is a fern-plant that during its early period of existence sends out an organ called a foot into the tissue of the prothallus, to absorb therefrom the food-material that the plant is as yet unable to obtain independently for itself. In the meantime it sends roots into the soil and a stem into the air, and when the prothallus is exhausted, it is ready to commence life on its own account.

In *Equisetum*, the Horse-tail, an ally of the fern, the processes are essentially similar, but the male and female organs (the antheridia and archegonia) are borne on separate prothalli, although the spores from which these arise are all alike.

In a higher branch of Vascular Cryptogams differentiation of male and female is carried back a further stage, for two kinds of spores are here produced. *Selaginella*, so common in our greenhouses, may be selected as a typical

* Prothalli are often found growing in the crannies of the wall of a greenhouse in which ferns have been standing, but the non-possessors of a greenhouse can easily procure prothalli by sowing spores in a pot of light soil, carefully watering them, and covering the pot with a bell-jar. The length of time the spores take to germinate depends on the species of fern from which they have been derived. Suppose that a prothallus has been found, that the little root-hairs on the under surface have been freed from particles of soil by careful manipulation under water with a camel-hair brush, and that it has been mounted in water on a glass slide, under-side uppermost, and covered with a cover-slip. It is now ready for examination under the high power of a microscope. By gentle pressure of the cover-slip the spermatozoids may be ejected from the antheridia, and may be seen wriggling through the water.

example. The male spores are much smaller than the female; hence their respective names, microspores and macrospores (μικρος small, μακρος large). The sporangia which contain these are termed microsporangia and macrosporangia respectively (Fig. II. *a.*). When the macrospore (*ma. sp.*) germinates, the prothallus does not come out of the spore, but remains as a mass of tissue, *without* green colouring-matter inside it, and in addition there is a nourishing material called endosperm, which later on becomes divided up to form a tissue of cells (Fig. II. *b.*). The male prothallus also remains inside the microspore. It consists of only one cell, and has no chlorophyll. A peculiar organ, termed the suspensor, develops from the fertilised egg, as well as the true embryo plant. It pushes the embryo into the endosperm, so that it may feed on it. It is noteworthy that the growth of the embryo takes place *inside* the spore, not outside, as in the two former cases.

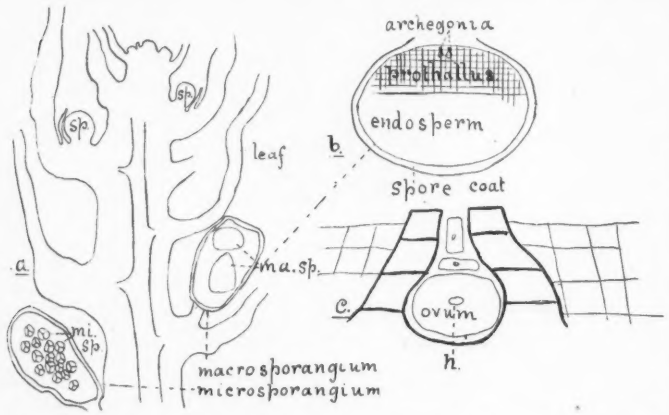

Fig. II.—*a.* Longitudinal section of apex of sporangium bearing shoot of *Selaginella*; *sp.*, developing sporangia; *mi. sp.*, microspores; *ma.sp.*, macrospores. *b.* Diagrammatic section of germinating macrospore. *c.* Ditto of archegonium (much magnified.)

The cone of *Pinus* (e.g. *Pinus sylvestris*, the Scots Fir), is a collection of leaves that have become modified to bear ovules, which afterwards are termed seeds. The ovule is a macrosporangium which, however, differs from that of Selaginella in that it possesses a covering or integument (Fig. III. *b.*, *in.*). The whole of the interior of the ovule is occupied by the prothallus. The male spore is familiarly spoken of as the pollen-grain, and the microsporangia as the anther-lobes or pollen-sacs; they are borne on the under surface of the stamens (Fig. III. *a.*, *st.*, *p.*) The pollen-grain is provided with two bladders or floats, and is carried by the wind to the ovules which lie exposed on the upper surface of the carpels or modified leaves on which they arise. The integument does not quite enclose the ovule, but leaves a small aperture, the micropyle (μικρος small, and πυλη a gate) for the reception of the pollen-grain. There the microspore (pollen-grain) enters and rests on the surface of the macrosporangium, germinates, and sends a tube (Fig. III. *c.* *d.*, *f.*; and *b.*, *p.*) into the microspore, where it comes into contact with the ovum, in one of the archegonia developed in the prothallus.

There is no endosperm in Pinus, as in Selaginella, but the important points to be noted are that not only does the embryo develop inside the macrospore, but the macrospore remains inside the macrosporangium that is still attached to the parent plant, from which it derives sustenance; for after the developing embryo has used up all the nourishment in the prothallus, fresh nutriment is poured into the macrospore from that source.

When the tube of the pollen-grain, which we may compare to an antheridium, touches an ovum in one of the archegonia, it sends part, at least, of its contents into it. As a result the ovum divides up to form a young plant (Fig. III. *e.*), that is provided with a long suspensor. The embryo is so placed that its root lies towards the micropyle. The mature ovule (macrosporangium) with its coat is the *seed*, and the collection of seed-bearing leaves which we find form what is commonly called a flower.

The Angiosperms (ἀγγειον a vessel, and σπερμα a seed) are so called from the fact that their seeds are enclosed by the leaves (carpels) on which they are borne; and in this they differ markedly from the Gymnosperms (γυμνος naked), such as the Pine, in which these are quite exposed. The majority of our familiar garden shrubs and forest trees belong to the large group of Angiosperms. A carpel may bear one or many ovules, which later on develop into seeds, and the carpel itself undergoes, as a rule, a characteristic change to form what we know as the fruit. The pollen-grains are found in sacs (anther-lobes or pollen-sacs)* situated on the upper portions of the stamens.

They are very similar to those of the Pine; but instead of having balloons they often possess warts or prominences by means of which they may adhere to the various animals that carry them to the stigmas of the carpels on which they must alight in order that they may be in a position to accomplish their *rôle* in life.

We have reserved until this stage a minute examination of the macrosporangium, or ovule—the organ that is of such vital importance in connection with the reproduction of the plant; the reason being that it is best to take for this purpose familiar examples such as may be easily procured by anyone desirous of making the examination of the object for himself. These are best found in the buttercups and daisies, the hyacinths and lilies of our fields, woods, and waysides. In all these cases the ovule is contained within the carpel or carpels, and the pollen-grain

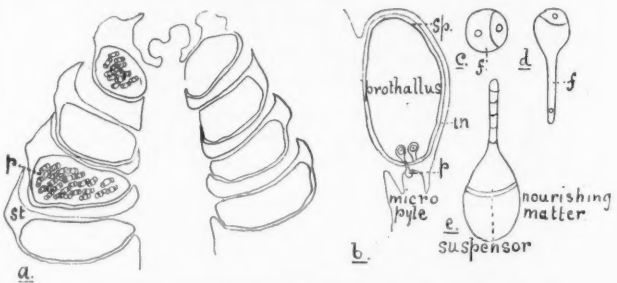

Fig. III.—*a.* Diagrammatic longitudinal section of male cone of *Pinus* (Scots Fir). Only two of the pollen-sacs are represented containing pollen-grains (microspores), *p.*; *st.*, stamen, with pollen-sac on under surface. *b.* Ditto of *ovule* of Pinus; *p.*, pollen-grain germination; *m.*, micropyle; *in.*, integument (coat) of macrosporangium (ovule); *sp.*, wall of macrosporangium. *c.* Pollen-grain; *f.*, cell which will develop into pollen-tube. *d.* The same, with cell (*f*) developed as pollen-tube. *e.* Diagrammatic representation of developing egg; there ought, in reality, to be four embryos figured arising from these ovules.

* See article on "Some Curious Modifications to Prevent Self-fertilization."—Knowledge, Feb. 1891.

can only effect an entrance to it by way of a tube (in many cases) in the style which opens to the exterior, in the stigma, and communicates below with the cavity of the ovary or ovule-containing portion of the carpel. The ovule is built up on the same plan as that of the Pine, but instead of being furnished with one integument, it has two, both of which completely enclose it with the exception of an aperture, the micropyle, so that the pollen-tube may be enabled to reach the macrospore. Fig. IV. *a.* shows a vertical section of an ovule of the Hyacinth (*Scilla nutans*) as it appears before fertilization; on the outside are seen the integuments, enclosing the wall of the macrosporangium. The part by which it is attached to the carpel is called the stalk, or funiculus (*f.*); *m.* is the micropyle. The macrospore is known as the embryo-sac; towards its micropyle end lie the ovum (*ov.*) and two cells, synergidæ, (*syn.*; συν with, and ἐργον work), which are thought to represent an archegonium, as they guide the pollen-tube to the ovum. At the opposite end there are three cells (*ant.*), termed the antipodal cells. They represent the prothallus which filled the whole embryo-sac in Pinus, and was an independent plate of green tissue in the Fern. It is, then, very much reduced here. This is the tendency in plants: the higher the plant, the greater the reduction of

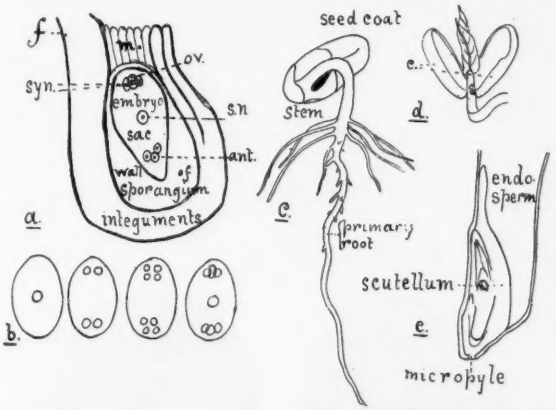

Fig. IV.—*a.* Diagrammatic section of ovule of *Scilla nutans* (Wild Hyacinth) previous to fertilization; *m.*, micropyle; *f.*, funiculus (stalk); *ov.*, ovum; *syn.*, synergidæ; *ant.*, antipodal cells; *sn*, secondary nucleus. *b.* Diagram illustrating development of embryo-sac (macrospore). *c.* Germinating Bean (*ad. nat.*). *d.* The same at a slightly later stage; *c.*, cotyledons; *s.*, young stem bearing ordinary leaves (*ad. nat.*). *e.* Diagrammatic section of portion of seed of Grass.

the prothallus stage of its growth. The central cell is the secondary nucleus. The remainder of the macrospore is filled with nourishing material.

It will be interesting to note how these cells have originated. We will go back to that stage in which the embryo-sac (macrospore) appeared as a single cell, when it was essentially the same as the Fern spore. All cells contain a nucleus, which is probably a part of its protoplasm that has become denser in structure, and perhaps changed in some other way. The nucleus is an important body, as in the division of cells it first divides up, and then becomes surrounded with protoplasm. The nucleus of the embryo-sac divides into two. The two thus formed similarly divide, and so do the resulting four nuclei. The positions they assume in each stage are shown in Fig. IV. *b.* Then one nucleus from each end of the macrospore travels to the centre. There they fuse to form the secondary nucleus. This stage is represented in the fourth diagram of Fig. IV. *b.*

The pollen-grain, when it has alighted on the stigma, commences to germinate, and sends a tube down the style, just as that of Pinus does; only here germination takes place on the stigma, whereas in Pinus it is effected on the macrosporangium (ovule) itself. The contents of the tube having fused with the egg, the latter divides up to form the embryo. At the same time the secondary nucleus splits up, and so on until the whole of the embryo-sac is filled with a tissue—endosperm, a mass of nourishing material. The developing embryo is furnished with a suspensor, as was that of Selaginella and Pinus, and, as in the latter case, development takes place in such a way that the root is directed towards the micropyle, and the first leaf or leaves, as the case may be, in the opposite direction. The reason of this arrangement will soon be obvious. All plants containing green colouring-matter (chlorophyll) obtain a large proportion of their food (at least the whole of their carbon) from the air. But when chlorophyll is absent the process of carbon assimilation, that is, the breaking up of the carbon dioxide of the air and taking up of the carbon and part of the oxygen, cannot go on, so the plant starves. This anyone can test for himself by growing plants in the dark; then chlorophyll will not be formed, what was previously there will disappear, the plant will assume a miserable, starved appearance, and will soon die, unless again brought to the light. However, place a potato in a dark, moist cellar (most cellars appear to possess these qualifications), and see what happens. A long, lanky plant will be produced. This will appear to contradict the statement just made; but a little consideration will show that it only apparently does so, for the potato is a storehouse of nutritive material on which the developing plant has been feeding. Whenever this store is exhausted, the plant dies. The ovule partakes in a great measure of the characteristics ascribed to the potato tuber. It is a reservoir of nourishing matter, in which the young plant is bathed at the commencement of its existence; this material it absorbs before it quits the seed.

For the examination of a mature seed we will take the common Garden Bean. It shows outside a scar or *hilum* that indicates the position of the short stalk which joined it to the carpel, and near the hilum is a small opening, the micropyle. Take a penknife and cut the seed-coat, and the contents will then fall out, and probably divide into two thick fleshy lobes, on one of which there is a knob-like process. This small process is the young plant, and the two fleshy lobes (Fig. II. *d.*, *c.*) are its seed-leaves or cotyledons, as they are ridiculously termed. However, this term must be remembered, as it is used in the naming of two large groups of Angiospermous plants—the Monocotyledons and Dicotyledons. The Monocotyledons (μονος one) have only one seed-leaf. Examples of these are found in the Lilies, Hyacinths, Irises, and Crocuses. They are further distinguished by the possession of leaves which have their veins running in a parallel manner. The Dicotyledons (δις twice), on the other hand, have two seed-leaves, and their leaves are net-veined. Our forest trees and many of our common garden plants afford us examples of these. The seed-coat is formed by the integuments and wall of the sporangium. The whole of the cavity of the macrospore, or embryo-sac, is occupied by the embryo plant and its enormously large cotyledons. The latter have absorbed the nourishing material that previously existed in the macrospore. A seed which, when mature, contains no nourishing matter is said to be *exalbuminous*.

We will compare this seed with that of a grass, such as the Wheat (Fig. IV. *e.*). A vertical section shows

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that the young plant occupies only a small part of the embryo-sac; the rest is filled with nourishing material, to absorb which a part of the stem of the embryo assumes a shield-like shape—scutellum—and applies itself to it. This is an *albuminous* seed; but the shield is not developed in all seeds of this kind.

When a seed commences to germinate, water is absorbed, and a great quantity of oxygen is taken in. The chemical processes which go on, the limits of this paper will not allow us to discuss. Let it suffice to say that the root passes out by the micropyle, and fastens the plant firmly in the soil. In the meantime, if the plant be albuminous, the embryo is absorbing the nourishing material by means of its seed-leaves, and living on it; while if exalbuminous, as is that of the Bean, the food-material contained in the cotyledons is gradually used up, so that these organs soon lose their fleshy appearance. By this time the plant has obtained a firm hold of the soil, and then the seed-coat is thrown off, chlorophyll appears in the leaves, and the young plant is enabled to start life on its own account.

NUMMULITES AND MOUNTAINS.

By R. Lydekker.

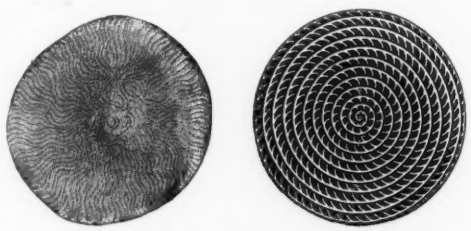
BOTH the proverb "as old as the hills," as well as the phrase the "everlasting hills," are but the expression of the natural tendency of the human mind to regard all hills and mountains as the most lasting and ancient objects with which we are familiar. As, however, is so often the case, science steps in and tells us that, although the proverb and the phrase are true enough as regards human experience, yet that when we go back and study the origin of things, as revealed by geology, we find that many hills and mountains—and more especially the highest of them—are actually among the very newest features in the physiognomy of the earth, and that the expression "as old as the plains" would, in many instances, be a far truer simile than the one current.

If, indeed, we reflect for a moment, we shall be convinced that the highest mountains of the globe—always excepting volcanoes, which have the power of renewing their height—must necessarily, as a general rule, be younger than many of those of lower height, or even than the plains from which they rise. Thus rain, snow, frost, and rivers are perpetually tending to wear down and wash away all the higher points of the earth's surface, and to carry the *débris* to the valleys below. Consequently, we are led to conclude that, *primâ facie*, the higher a mountain range is, the less time it has been subject to this washing-away process, and, therefore, the younger it is as regards relative age. It might, indeed, be objected to this that the mountains that are now the highest have always been the highest; and that at the beginning of all things their original height as much exceeded their present height as the latter does that of the smaller ranges. In this view, however, their original heights would have had to be so stupendous as to be almost inconceivable, and probably much greater than is compatible with the physical conditions of the globe. This hypothesis may, therefore, be dismissed as untenable; more especially as there is direct evidence of a totally different kind, which is conclusive as to the truth of the alternative view.

This evidence is afforded by fossils, and more especially by a particular kind of fossil, which, from its abundance and the restricted geological epoch in which it is found, is of more than usual value in inquiries of the present nature.

If any of our readers have ever examined the Tertiary clays and sands of Barton, in Hampshire, or of Brucklesham, on the Sussex coast, they will probably have met with numerous disc-like objects, the larger of which are somewhat more than an inch in diameter, while the smallest are scarcely bigger than a pin's head. When split or cut, these objects are found to contain a number of minute chambers, separated from one another by thin walls arranged in the form of a spiral, as shown in the figure. Technically they are known as nummulites, and belong to the very lowest division of the animal kingdom—lower even than the sponges, which some people cannot be persuaded to believe are animals at all. Now these nummulites are exceedingly interesting to those who study the growth and formation of mountain ranges, for the reason that they occur, in any quantity and of large size, only through the greater portion of the Eocene or lowest division of the Tertiary (latest) geological period, although not reaching down to the London Clay; and also because they were very widely distributed in the seas which then covered a large part of our existing continents. If, then, we should find rocks containing great numbers of large nummulites on the flanks or tops of a mountain range, we should be assured that such range was younger than the Eocene period, at which date its component rocks were being formed as mud at the bottom of the sea.

Now, although in England the aforesaid nummulites only occur in soft beds of clay and sand in the low cliffs of the southern coast, when we cross to the Continent we find them forming the greater part of a massive limestone, known as the Nummulitic Limestone. This very characteristic rock is more massive and more widely spread than any other Tertiary deposit, and, in its thickness and



A Nummulite, viewed from above, and Horizontally Bisected.

identity of structure over large areas, recalls the Mountain Limestone of the Palæozoic epoch. It is, indeed, absolutely one mass of nummulites, of which sections are displayed on every fractured surface; and it was probably an open sea deposit, which must have taken incalculable ages for its formation. It occurs in Southern Europe in both the Alps and Pyrenees, attaining a thickness of several thousand feet in the former, and occurring at elevations of more than 10,000 feet above the sea-level. In the Pyrenees it forms a beautiful white crystalline marble. On the south of the Mediterranean, Nummulitic Limestone is found again in the mountains of Algeria and Morocco. In Eastern Europe it reappears in the Carpathians, and thence may be traced into the Caucasus and Asia Minor. All travellers to India are familiar with the Mokattam range of bare mountains on the western shore of the upper part of the Red Sea, which are likewise almost entirely composed of this same limestone. It is, indeed, a common belief among the Egyptian peasantry

that the larger disc-like nummulites are lentils left by the builders of the pyramids, and subsequently turned into stone. From the Caucasus and Asia Minor the Nummulitic Limestone may be followed into Persia, Baluchistan, Sind, the Punjab, and so into the Himalaya. Thence it continues into Assam and Burma, and reappears in the Andaman and Nicobar Islands in the Bay of Bengal.

It is, however, in the inner Himalaya that the occurrence of Nummulitic Limestones and certain overlying Tertiary rocks is of more especial interest, since it is there that they attain a greater elevation than in any other part of the world. It is in the upper Indus Valley, in the neighbourhood of Leh in western Tibet, that these nummulitic rocks occur; running some distance down the Indus to the west of Leh, and to the eastward of that town extending into Chinese territory. There is good evidence to show that the arm of the sea in which these nummulitic rocks were deposited communicated with the ocean to the eastward in the Bay of Bengal, instead of following the course of the Indus in a westerly direction to the Arabian Sea. Moreover, in some parts of this area the rocks which overlie, and are, therefore, newer than the Nummulitic Limestone, are raised to the stupendous elevation of more than 21,000 feet above the sea-level.

We have, therefore, before us decisive evidence to show that those parts of the earth's surface which at the present day form some of the highest peaks in the Himalaya were, at the period when the London Clay was deposited, below the level of the sea; and consequently that the elevation of that part of the Himalaya has taken place entirely since that epoch, during a period when the physical features of England have altered only to a comparatively slight degree. There is, moreover, equally conclusive evidence to show that the elevation of the Himalaya was not completed until a much later epoch of the earth's history, since on the southern flanks of this mighty range we find beds of sandstone containing remains of mammals which lived during the Pliocene, or later Tertiary epoch, raised to a height of several thousand feet above the sea-level.

The elevation of the Indus Valley in the heart of the Himalaya could not, therefore, have commenced until the Miocene, or middle Tertiary epoch, while that of the outer Himalayan ranges could not have been completed till far into the Pliocene period, and, for all we know to the contrary, may still be in progress. Not only so, but the same evidence likewise tells that the Alps, Pyrenees, Carpathians, the Caucasus, and the Egyptian Mokattam range, as well as the mountains of Algeria, have all attained their present elevation since the latter part of the Eocene period, when at least a considerable portion of their area was submerged. And we accordingly learn that many of the most striking physical features of the Old World are of comparatively modern origin.

When, however, we turn to mountains like those of the Lake District and Wales, which only attain moderate elevations, and in which the rocks belong solely to the Palæozoic, or oldest geological epoch, it is evident that we have to do with elevations of an extremely remote date. There is, indeed, satisfactory proof that these old mountains were once vastly higher than they are at present; their diminished altitude being due to the long ages during which they have been subjected to the wear and tear of the elements. To such mountains the proverb to which we have already alluded is, therefore, strictly applicable; but in a geological sense the phrase "everlasting hills" can be applied neither to the oldest nor the youngest mountains.

DISSEMINATION OF SEEDS.

By Theodore W. Dicker.

THE dispersion of seeds over the wide surface of the globe, which has been of so much importance in the distribution of vegetable life, has been accomplished by adaptations as marvellous as they are effective. In these methods we find another proof of Nature's firm determination to carry on the race. First we have the astonishingly lavish manner in which seeds are produced. Eight thousand have been counted in a single capsule of the White Poppy, whilst it has been estimated that a single Tobacco-plant can produce 360,000. How multitudinous, too, are the microscopic spores of the Flowerless Plants. It has been calculated that a single frond of Spleenwort could produce a million spores, and it is necessary to only slightly kick a mature Puff-ball (Lycoperdon) to drive the spores out in a small cloud. Why, then, it may be asked, with all this tremendous reproductive potency, is not the earth overrun to a most inconvenient extent by plant-life? The possibility of overproduction is checked in many ways, among which are the unsuitability of position, the destructive struggle for existence which goes on among crowded plants, and by the great consumption of seed by men and the lower animals.

In addition to the exuberance of production we must take into consideration the power which seeds and fruits possess of resisting injury. They are less perishable than any other part of the flowers producing them, and are well adapted to retain their vitality, even through great changes of temperature, for a length of time. Some wheat which Sir George Nares brought from the Arctic regions, where it had been left by the crew of the *Polaris* two years before, was found to still possess its germinating power; and Dr. Trimen states that some seeds of Nelumbium in the herbarium of Sir Hans Sloane, who died in 1753, germinated in 1866.

In the distribution of seeds we find three kinds of agencies concerned, sometimes acting independently and sometimes in concert. First, there are the remarkable efforts which plants themselves make to disseminate the products of fructification; secondly, there is the powerful instrumentality of two inanimate forces without, viz. wind and water; and, lastly, there is the unconscious but interested action of animal life.

Let us examine first the methods by which plants themselves seek to insure the proper disposal of their seed. Dissemination generally begins at the close of life in annual plants, and at the "period of rest" in woody plants. It is then, except in the case of succulent fruits, that the fruit attains the degree of dryness necessary for the liberation of the seed. Indeed, fruits may be roughly divided into dry and succulent. As succulent fruits generally exhibit no particular mechanical efforts in themselves at dissemination, it is with the former, or dry fruits, that this part of our article is concerned. Dry fruits, again, may be separated into the *dehiscent*, or those in which the pericarps, or seed-cases, open to permit of the escape of the contained seeds, such as the Pea-pod, and the *indehiscent*, or those in which the pericarps do not open. Taking first the *dehiscent* fruits, we find that they usually consist of a number of seeds enclosed in tough pericarps, as in the Poppy or the Vetch. As such fruits present no special attraction to animals, the seed-cases must of necessity open to permit of the exit of the seeds; for where the seeds are numerous it would manifestly be to their disadvantage if the fruit merely fell to the earth and they escaped only through the rotting of the seed-case, as this would

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set up a struggle for existence in which only the most capable would survive. Fruits of this kind therefore split in a regular and distinctive fashion in order that the seeds may escape. And not only do the pericarps prevent a crowded planting by thus splitting, but they frequently still further carry out this important object by ejecting the seeds with considerable force. The methods by which this is achieved are most curious and interesting. The legume of the Pea splits along its two margins, the two halves falling away from each other and throwing off the seeds in various directions. The seed-cases of the Pansy and of the Violet explode, scattering the seeds forcibly. In the Gorse and the Broom a sudden burst of the pods and a spring-like twist of their two halves effectually disperse the contents. On sunny July days the cracking sounds produced by the bursting pericarps may be distinctly heard. The mature fruit of *Ecballium elaterium* separates from its stalk and ejects its seeds with great rapidity through the orifice left by the rupture. The sporangia of many ferns (Bracken) have an elastic ring which is probably intended for the energetic dispersal of the spores. In certain pines the scales of the cone, when thoroughly dried by the hot days of the summer following that of its production, open with a jerk, forcibly ejecting the winged seeds. Frequently a number will burst together, and then the sound may be heard at a great distance. In the expulsion of the seeds of the Balsam (*Impatiens*) the contact of some outside object is of advantage. The seed-case consists of one cell with five valves, and, if touched by accident when ripe, it at once bursts open, the valves coiling themselves violently, and, springing from the stalk, scatter the seeds in all directions. In the Poppy and the Snapdragon a still larger share of the work of releasing the seeds falls to an outer agency, for here the pericarp consists of a capsule which opens along the top by valves that leave small pores through which the seeds fall out when the capsules are shaken by the wind. In all of these various methods of the expulsion of seeds it would seem that they are due to mechanical causes, and depend in most instances (*Impatiens* excepted) upon a certain condition of dryness in themselves, and upon the state of the surrounding atmosphere.

Passing from the modes in which dry fruits, consisting of a number of seeds enveloped in tough pericarps, effect dissemination, we have to consider next the means which obtain among dry fruits whose seeds are not collectively enclosed in a strong seed-case. Here, too, we find the forcible ejection of seeds. Those of the Oat are scattered with such energy that on a fine, dry day the snapping thus caused is distinctly audible. But the most curious provision possessed by seeds of this class for self-dissemination is the hygroscopic awn. In the Wild Oat (*Avena fatua*), for example, there is attached to the glumella (a small leafy structure connected with the seed), a spiral awn covered with numerous fine hairs, and this awn has the power of expanding when moist, and of contracting when dry. Thus the attached seed is constantly on the move with the changes in the weather, the hairs clinging to any object met with, until germination or destruction puts an end to its motion. The seed of Barley, too, is provided with a similar awn, which is furnished with minute teeth that point towards its apex. The seed, when lying on the ground, naturally expands with the moisture of the night, and contracts with the dryness of the day; but, as the teeth prevent its moving towards the point of the awn, all motion must be in the direction of the base of the seed, which will thus travel many feet from the parent stalk. As a ready proof of this, an ear of Barley will, if placed seed uppermost in the coat-sleeve in the morning, be found to work up to the arm-pit during the day. A still more remarkable provision exists in Erodium, a genus belonging to the Geranium order, by which the seed buries itself. The fruit splits into five cone-shaped seeds, at the base of which is a long awn or filament. As the seed lies on the ground the awn remains straight so long as it keeps moist, but when it gets dry one side of the awn contracts, forcibly causing the upper end to form a curve which brings its point against the ground, and the apex of the conical seed downwards. The lower part of the awn now commences to contract into a spiral, causing the cone to rotate and to enter the earth where the hairs which it bears, and which point upwards, hold it fast. The spiral portion also enters the ground, forcing the seed downwards. Moisture now, instead of reversing the effect produced by dryness, only continues it, for the spiral coils, in trying to straighten themselves, are held fast by hairs, and the result is that the seed is driven deeper into the ground. It is a notable thing, as Mr. Francis Darwin has pointed out, that these burying contrivances are all of a similar nature, though belonging to plants of widely separated orders.

Having considered plants which possess special facilities in themselves for dissemination, we come to those which depend to a great extent upon outside agencies for their dispersion. Of these agencies, the all-pervading instrumentality of the wind may be taken as naturally next in order to the power of self-distribution. The exceeding smallness of many seeds, not to speak of spores, admits of their ready transport by the wind. In addition to this, certain fruits are evidently intended for dissemination by this agency, for they are furnished with downy tufts or with wings which support them on the breeze. When ripe for dispersion, the light, flossy seeds of the Dandelion and the Thistle may be seen floating in considerable quantities on the softest wind. These special appendages, though designed to serve the same purpose, and though often similar in appearance, vary greatly in their origin. There are three kinds of wing-shaped processes which, while the fruit is developing, take their rise from different parts of the flower. The wings on the seeds of certain species of the Pine Order arise from an outer layer of the tissue of the scale; those on the seed of *Bignonia muricata* from the coat of the ovule, and those on the samaræ of the Elm and the Maple are developments from the pericarp, which, of course, in simple fruits is the matured ovary. Again, the silky tuft of hairs, or pappus, of the Compositæ and of kindred orders, is a peculiar development of the calyx; whilst the coma of the seeds of Asclepias and of the Willow is a hairy growth from the testa. Aided by these special formations on seeds and fruits, the importance of the wind in the work of dissemination is difficult to overestimate.

Frequently the wind acts in conjunction with another outside agent of dissemination—water. The wind strips the vegetation of a district of its fruits and carries them into neighbouring streams, to be caught perhaps by the bend of a bank where they form a colony. Plants growing by the banks of rivers will thus be distributed along the course of the stream. Curiously enough, it will sometimes happen that an Alpine plant will in this manner be brought into a lowland district where the climatal conditions are not favourable to its growth. It may flower, but cannot produce seed, and it is only by the continual renewal of the seed by the current that the species is able to maintain its occupation of the uncongenial locality. Certain seeds will, however, be borne by the current right out to sea, where, with others which have been carried

direct to the ocean by the wind, they may probably flourish on some remote island. Necessarily such seeds must be well protected against outer injury, whether from friction or from the action of salt water. Dr. Hooker found in his examination of a large number of the floras of islands that the Leguminosæ, to which order the Pea, the Vetch, and the Bean belong, contained more species common to other parts of the world than any other order. The preponderance was due to the characteristic form of the fruit, its strong pericarp being well adapted for preserving the seed, whilst its shape enabled it to float on the water.

Of course, it is only fruits of a certain lightness and buoyancy that admit of transport by wind and water. Those that are too heavy for this method of distribution, such as pulpy fruits, depend upon the agency of animal life for dispersion. There can hardly be any doubt that the bright, succulent, and edible coverings of fruits are specially intended to attract the attention of birds and other animals. In order to produce this attractive exterior we find not only the ovary—afterwards the pericarp proper—specially developed, as in the Orange or the Grape, but various other parts of the flower.

Thus, by structural developments adapted to take advantage of the means of transport existing in the forces of wind and of water, and in the surrounding animal life—affording another proof of the interdependence which exists in Nature—have plants been spread over the Earth. "The real difficulty," says Sir Charles Lyell, "which must present itself to everyone who contemplates the present geographical distribution of species, is the small number of exceptions to the rule of the non-intermixture of different groups of plants. Why have they not, supposing them to have been ever so distinct originally, become more blended and compounded together in the lapse of ages?"

CALCITE AND ARAGONITE IN SHELLS.

By Vaughan Cornish, B.Sc., F.C.S.

If different materials have the same chemical composition, they are generally regarded as being essentially identical, and are looked upon as *varieties* of the same substance. Carbonate of lime is a familiar example; chalk, limestone, marble, Iceland spar, and aragonite are all composed of carbonate of lime, and are spoken of as different varieties of carbonate of lime. This does not, however, represent the view of the mineralogist. Chemical composition is only one among several criterions considered in the definition of a mineral species. It often happens that minerals differing fundamentally in their crystalline form, and in the internal structure which is connected with the external form, have the same chemical composition. These are regarded by the mineralogist as distinct species, notwithstanding the identity of chemical composition. Fundamental difference of crystalline form is the basis of differentiation among minerals of which the composition is identical. We will endeavour to make clear the principles on which it is decided whether a difference of form is to be regarded as fundamental. In mineralogical collections, ranged side by side with the well-known rhomb of Iceland spar, may be seen a vast variety of crystalline forms of carbonate of lime. In general appearance they differ greatly from one another; yet the mineralogist will tell one that there is no *fundamental* difference in these forms, which are all intimately related to that of the rhombohedron. This relationship is a matter of geometry, which we must be content to state merely in a general manner. A crystal is a body bounded by certain plane surfaces—the faces of the crystal. The arrangement of a system of planes is best understood by considering how their position is related to three lines intersecting at a point, these lines being termed *axes*. A crystalline form is defined, first, by the position of these lines; secondly, by the manner in which the position of the planes is related to that of the lines. All the various forms which, in the mineralogical collection, are placed in proximity to the rhomb of Iceland spar, are forms which can be built up on the same system of axes, and the positions of the planes or faces with respect to these axes are all related to one another according to a simple geometrical law. All these specimens are, therefore, reckoned as belonging to one mineral species, to which the name *calcite* is given.

In the next compartment of the mineralogical collection will be found another set of crystals, also composed of carbonate of lime. These, however, are members of another mineral species known as *aragonite*. Their forms are related among themselves by a simple geometrical law, but the plan of construction is radically different from that of the calcite forms. The system of planes representing the faces of the crystals cannot be built up on the same three axes as those of the calcite forms, and the law connecting the positions of the planes themselves is different in the two cases.

For the mineralogist, carbonate of lime comprises two mineral species—calcite and aragonite—and all the different varieties are classed under one of these two names.

The question may be asked, Is there not something fanciful in basing a classification of material substances merely on certain abstract ideas of symmetry? Calcite and aragonite are composed of the same kinds of stuff or matter; if our minds were not gifted or encumbered with abstract notions about symmetry, should we discover any difference of properties between these two mineralogical species? As a matter of fact, the properties of crystalline substances furnish a striking example of the real and intimate relation of our ideas of symmetry with the actual constitution and properties of matter. Every property of a crystalline substance is related to the particular symmetry of its form. Thus, take the case of the action of the substance upon light. A ray of light is affected in the same way by its passage through any crystal of calcite; all specimens of aragonite behave alike in their action on light; but the mode of action is entirely different in the case of aragonite from that of calcite. For exhibiting these differences of behaviour in the most distinct manner an elaborate instrument is employed, the stauroscope, in which *polarized* light is used. We cannot enter here into the method of using the instrument, but in most text-books of mineralogy will be found plates showing the different *interference* phenomena afforded by a crystal of calcite and one of aragonite. A fragment of a crystal shows the phenomena characteristic of its species, which do not depend upon the specimen possessing crystalline faces. The action upon light depends upon the actual structure of the material of which the crystal is composed, which, as the above example shows, is intimately related with the crystalline form. We see, then, that the physical properties justify the mineralogist in sorting the varied crystalline forms of carbonate of lime into two classes, and in characterizing every member of each class by one of two names—the names of two mineral species.

We have said that *all* varieties of carbonate of lime are classed as calcite or aragonite, and many of these varieties do not show crystalline form at all, as, for instance, limestone and marble. What data justify the

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mineralogist in calling limestone and marble calcite? We have said that where crystalline symmetry differs, all physical properties are different. One of the most important, and one of the most nearly constant properties of every kind of matter, is its specific gravity. Every specimen of calcite has a specific gravity of 2·72, or not differing from 2 72 by more than one or two units in the second decimal place. Similarly all specimens of aragonite have a specific gravity of very nearly 2·93. In limestone and marble we have the so-called *massive* carbonate of lime, the material not having had the opportunity to assume the crystalline form. How are we to determine whether limestone is calcite, aragonite, or yet another mineral species? The specific gravity is found to be that of calcite, viz. about 2·7, as is also the case with marble. We conclude, therefore, that the carbonate of lime in limestone and marble is calcite.

It has long been a familiar fact that certain organisms have the power of secreting carbonate of lime from solution to build up the hard portion of their shells. The shell of the oyster, for instance, of the crab, and of the common whelk are complex structures of organic matter and carbonate of lime, and in the fossilized remains of shells the general form of the shell is preserved by the carbonate of lime after the decomposition of the organic matter. Several questions of interest are suggested by this case of combined mineral and animal growth. Does the carbonate of lime in calcareous organisms exist in some special modification different from those known in the mineral world? How far is the mode of growth of the animal tissues constrained by the rigid laws of crystallization? Or, on the other hand, do the forces brought into play in animal growth mask, or even overpower, the operation of the ordinary process of the crystallization of a substance from solution? The answers to these questions are furnished by the investigations of Dr. Sorbey and others, which have been published at intervals during the last twelve years. In the first place, it has been shown that in calcareous organisms we have *not* to deal with any new species of carbonate of lime. In every case the optical properties and the specific gravity show that the shells contain either calcite or aragonite. Some animal species secrete carbonate of lime as calcite, others as aragonite.

The mode of growth of the shell is in general a compromise between the mineral and the organic, in some cases the influence of the first factor having the predominance, in others that of the second. The direction of the *principal axis* of the crystal is always related in a definite manner to the surface of growth of the shell—the symmetrical arrangements which result from this relation producing very beautiful appearances when sections are examined under the microscope. Thus the inner shell of *sepia* (the cuttle-fish) shows innumerable crystals of aragonite ranged in parallel rows, whilst the mineral portion of the spines of *echinoderms* consists of a single crystal of calcite greatly developed in one direction.

Some organisms, as we have said, secrete or produce calcite, others aragonite. Other cases again are known in which one portion of the shell is built up of, say, aragonite, and during the subsequent growth of the organism its habits or powers undergo a change, the rest of the shell being built up of calcite. It will be seen that we are dealing with a mixed study, at once mineralogical and biological. It is peculiarly interesting to find that the influence of the laws of evolution is apparent even when studying the mineralogical aspect of the subject. It is well known that the embryo shows the past history of the species, the development of the individual furnishing an epitome of the history of development in the race. Now the shell of the common whelk, which may be found on any sea-beach, is composed of calcite, except a small portion which is that *first* formed in the growth of the organism. The examination of the *fossil* species of the whelk tribe shows that they are composed wholly of aragonite, the composition of the whole shell of the early individuals of the race being identical with that of the embryo of their modern representative.

It was long since observed that in fossiliferous beds which are permeable to water, certain calcareous shells are preserved, whilst others are only represented by their impressions. This is the more remarkable, because some of the most massive shells have disappeared whilst others of delicate structure remain. The form of the impression enables the species of the shell to be identified, and it is found that the shells which have been removed are those of species known to secrete their carbonate of lime as aragonite. It was known that under many conditions aragonite is less stable than calcite, and it was assumed from the above observations that aragonite is more readily dissolved than calcite by water containing carbonic acid. A few years ago this point was made the subject of experimental investigation, with somewhat singular results. Pure and well crystallized specimens of calcite and aragonite were subjected to the action of a solution of carbonic acid under similar conditions. No difference of solubility was detected. Powdered calcite and aragonite fossil shells gave a like result. It was found, however, when the complete shells were suspended in a solution of carbonic acid, that those of aragonite were much more readily acted upon than those of calcite, and further that the coherence of the shells was soon destroyed, so that the slightest agitation of the water was sufficient entirely to disintegrate the shell, reducing it to the condition of a fine powder or mud. The disappearance of aragonite fossils is explained by these experiments; it is due not to the greater solubility of aragonite, but to a mode of structure of shells composed of aragonite which facilitates their solution and disintegration.

The experiments gave somewhat unexpected results also in the case of calcite fossils. It was found that they were acted upon with considerable rapidity by the solution of carbonic acid, but that they retained their compactness, and even the delicate details of marking, after losing as much as 15 per cent. of their weight through the action of the solvent. It is thus evident that the calcite fossils found in porous or permeable beds *simulate* an immunity from the action of carbonic acid which they do not in reality enjoy. In such beds as these a large quantity of carbonate of lime goes into solution, and cavities are formed having the shape of the fossils which have been removed. It frequently happens that at a subsequent period carbonate of lime crystallizes out from solution in these cavities. When crystallization takes place at the ordinary temperature calcite is formed, a fact which is readily established by laboratory experiments. Consequently *casts* are formed in calcite of aragonite fossils. They are readily distinguished from the originals by their translucency, aragonite fossils being always opaque. Thus the beautiful *ammonites* often found of a material resembling fine alabaster are repliquas only, no trace of the original aragonite shell remaining. Many other such cases occur.

In conclusion, we may point out that the investigation of the subjects dealt with in this article involves the application of chemistry, mineralogy, and palæontology. The work has been taken up from time to time by students of one or other of these sciences, but the subject as a whole belongs to a sort of no-man's land in science. The border-

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HEAD OF RAMESES II., THE PHARAOH OF THE OPPRESSION
Found January 9th, 1891, in a mound of rubbish outside a Temple facing the Nile at Luxor.

Direct Photo Eng. Co., Lim., 9, Barnsbury Park, N.

INTAGLIO PICTURE OF THE FRONT OF THE TEMPLE OF RAMESES II.
As it existed at the time of its dedication to Amun-Ra. Uncovered 7th January, 1891.

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lands of the different sciences are apt to be somewhat neglected, but often yield a fruitful harvest to an investigator properly equipped for his work.

EXCAVATIONS AT LUXOR.

By Canon Isaac Taylor.

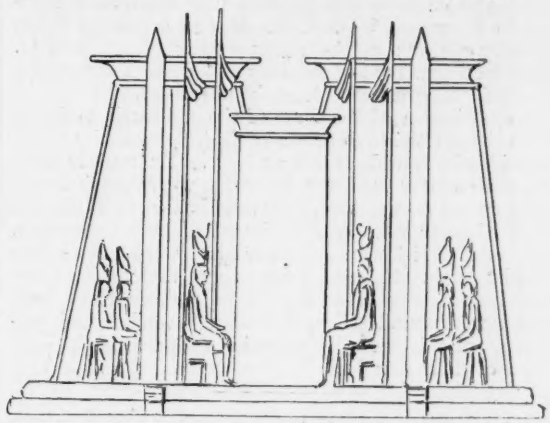
LUXOR is one of four or five villages occupying portions of the site of Thebes, at one time the greatest city in the world. These villages, mere collections of mud huts, were built in the chambers and against the walls of temples and palaces, which were grouped in certain parts of the area of the ancient city. The word Luxor is merely a corruption of the Arabic name *El-Kusur*, which means "the palaces," and was applied to a range of connected temples extending for nearly a quarter of a mile along the eastern bank of the Nile. These temples were, till recently, buried under a vast mound of *débris*, some twenty or thirty feet in height, consisting of broken pots, the refuse of habitations, and the crumbled mud bricks of successive huts and houses of unburnt brick which had accumulated during the last 1,400 years. The sections of these refuse-heaps show in some places fifteen to eighteen strata, the strata representing successive houses, each built on the ruins of a house which had formerly occupied the site. By the means of the new tourist tax—a tax of £1 now levied on each visitor who ascends the Nile—these temples are rapidly being cleared from the rubbish which is piled up in their courts and colonnades, and the sculptured scenes which cover the walls are being daily exposed to view.

During the present season, 1890–91, the great temple of Rameses II., the Pharaoh of the Oppression, has been nearly cleared. Outside the northern portal, which fronts the Nile, are two colossal statues of Rameses, monoliths of red granite in a standing position; while the more important entrances, those to the east and the west, are each guarded by two seated statues of the same king, monoliths of black granite. The scale is rather more than six times the size of life, and as each statue is surmounted by the lofty crown of Upper Egypt, they would, if in an erect position, have represented figures nearly forty feet in height. Unfortunately most of them have been defaced by iconoclastic zeal, the faces especially being mutilated. In one case, however, the destroyers, instead of mutilating the features, succeeded, with the aid of wooden wedges inserted into holes bored behind the neck, in detaching the whole of the head. In its fall the head broke in two pieces, the crown breaking off at the forehead. In the first week in January this gigantic crown, about four feet in height, was discovered by the excavators, and a few days later they came upon the head itself, the face being absolutely uninjured, and wearing the placid smile of amused contempt with which the features of Rameses were commonly represented by the sculptors of his court. The picture to the right hand is from a photograph taken a day or two after the head was uncovered. The Arab seated beside the head is a tall man, not far from six feet in height.

Royal Crown.

Two days before this discovery was made, the workmen uncovered a portion of the inner wall of the temple, on which is sculptured a most interesting representation of the dedication of the completed temple to Amun-Ra. On a portion of the wall, about six feet by four, we find in shallow intaglio a picture of the temple as seen from outside the western pylons, a picture which disposes of sundry conjectural restorations of Egyptian temples, and shows how the pylons, obelisks, and flag-masts were arranged.

The picture engraved upon the wall is on a scale of about 1 to 22. It shows the two gigantic pylons, which have suffered little injury, and between them is the lofty portal,



This Sketch is the same as the Intaglio Picture of the Front of the Temple in the Photograph.

which has now entirely disappeared. In front of each of these pylons stood an obelisk of red granite. That to the left is still standing, though buried for about a third of its height in rubbish. The fellow obelisk to the right is now in the Place de la Concorde,* at Paris. Two gigantic masts, bearing flags, stood in front of each pylon. The stone attachments for these masts can still be traced. To judge by the scale, the masts must have been more than seventy feet in height, and the flags must have floated from them at about the height of the pylons. The pylons were guarded by six colossal statues of Rameses—two in a sitting posture, and four erect. The seated figures are now nearly buried in rubbish, leaving the heads only above ground. Of the standing statues the one farthest to the right has been dug out, and is in fair preservation, the accumulation of soil having reached above the head. Of the next standing statue nothing remains. Of the two standing colossi to the extreme left in the picture nothing can be seen; but, as the soil is undisturbed, they may possibly be found, either in fragments or *in situ*, when the excavators have reached that portion of their task.

The picture has decided another interesting point. From other temples it is known that the pylons were provided with internal staircases by which their summits could be reached. Within the last fortnight† the excavators have discovered the internal staircase leading to the summit of the great temple of Rameses III. at Medinet Haboo. Now it will be observed in the drawing that near the foot of each of the obelisks three steps are indicated, and these must be the lowest steps of the staircases which led to the summits of the pylons. We know, therefore, that by the removal of some twenty feet of rubbish the excavators will come upon the entrance to the staircase, which, it may be hoped, will prove so far uninjured as to make the ascent practicable.

It may be mentioned that the western faces of the

* The actual height of the obelisk in Paris is 82 feet, while the representation of it in the wall picture is 45 inches high, giving 1 to 22 as the scale. The masts must have been something like 80 feet high. Where did Rameses obtain such timber?

† The article was written by Canon Taylor at Luxor, and posted 20th January 1890.—A. C. Ranyard.

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pylons are covered with battle-scenes, representing the Syrian campaign of Rameses II., including the battle under the walls of the city of Kadesh on the Orontes.

In the interior of the temple, in addition to the seated colossi already mentioned, eleven gigantic standing statues in red granite have already been unearthed, and there must be three more beneath the floor of a mosque which still occupies the south-western corner of the temple. These, on account of the religious prejudices of the people, cannot, for the present at least, be unearthed.

The mutilation of the faces of the figures is probably due to the fanaticism of the early Christian hermits of the Thebaid, who regarded them as idols. Fortunately there is no such danger from the Moslems, who, though iconoclasts, do not regard the statues as images or idols, but believe that they are the bodies of their own ancestors, who, as a punishment for their sins, were turned into stone by Allah. The other day one of these statues was unearthed, and the next day at early dawn three Arab women were found solemnly walking round it, and performing suitable funeral ceremonies, as if around the body of one of their own dead.

The following extract from a translation of a private letter addressed by M. Grébaut, director-general of the excavations, to his learned predecessor, Professor G. Maspero, of Paris, was printed in the *Times* of March 2 :—

"Having found, *in situ*, at Deïr-el-Bahari, a royal sarcophagus of a queen, and seeing that the surrounding ground had not been disturbed, I thought it worth while to make further excavations on the spot.

"At a depth of 15 mètres we came upon the door of a rock-cut chamber, in which were piled, one above the other, 180 mummy-cases of priests and priestesses of Amen, together with a larger number of the usual funerary objects, including some fifty Osirian statuettes. Of these, we at once opened ten, finding a papyrus in each.

"There are a great many enormous wooden sarcophagi, containing mummies in triple mummy-cases, all very richly decorated. Among these we have found a priest of Aah-hotep. These sarcophagi are of the time of the 21st dynasty. What we have found is, therefore, a 'cache' of the same period as that of the royal mummies discovered in 1881, and made by the same priests of Amen.

"Notwithstanding that the soil has remained untouched for 3,000 years, some of these sarcophagi are broken, and many of the gilded faces of the superincumbent effigies are injured. The way in which they are piled up, their damaged condition, and the general disorder, point to a hurried and wholesale removal, as in the case of the royal mummies. We find, for instance, a mummy-case inscribed with one name, enclosed in a sarcophagus inscribed with another, while probably the inner cases may prove to belong to a mummy with a name differing from both. May we here hope to find some royal mummies for which there was not space in the vault discovered ten years ago? I scarcely dare to hope it.

"At a first glance it would seem as if the high priests had abstained from burying the mummies of their more humble predecessors with those of royalty. Everything must, however, be opened and studied.

"About midway in the shaft now open may be seen the door of an upper vault; and, to judge by certain indications, there is also probably an intermediate vault; had we, however, only the 180 sarcophagi contemporary with, or anterior to, the 21st dynasty, it would be a magnificent haul, the greater number of the sarcophagi being really splendid and in perfect preservation. There are also some charming things among the minor objects.

"The name has been purposely erased, or washed off, from several of the large sarcophagi, and the place left blank, as if the scribe had not had time to fill in that of the new occupant; but we may probably find the names of those later occupants on their inner mummy-cases. One of the largest of these sarcophagi is surcharged with the name of the High Priest of Amen, Pinotem.

"As soon as we have cleared the lower vault I shall attack the upper chamber, or chambers."

Letters.

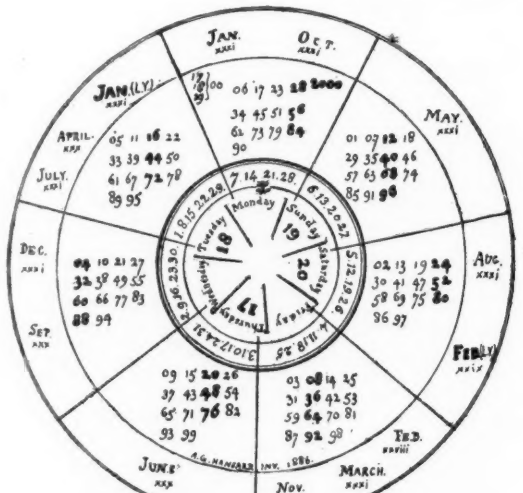
[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

PERPETUAL CALENDARS.

To the Editor of Knowledge.

Sir,—I was much interested in Mr. Prince's calendar, inasmuch as I designed one myself on much the same lines a few years since. Mine, however, seems to have some advantages for finding the days of the week in past centuries (especially in the Old Style). I therefore enclose a copy and the rules for using it, in case you should think it of sufficient interest to reproduce for the readers of Knowledge.—Your obedient servant,

Arnold S. Hansard.



Rules for Using the Table.

I.—The numbers in the ring next within the names of the months are the last two figures of the years; the numbers in the ring next inside this are the days of the month. The numbers on the movable disc refer to the first two figures of the years (*i.e.* when the given date is within the years 1700 and 2099 N.S.).

II.—To find the day of the week of any given date (N.S) where the first two figures of the year are given on the movable disc; firstly, bring that number opposite to the last two figures of the given year; secondly, note which day of the week is thus brought under the small arrow at the top of the movable disc, and bring that day

of the week under the required month. The days of the week are now opposite their proper days of the month.

III.—If the year is given in thick figures it is a Leap Year, and the January and February in thick letters must be used; in other cases the plain January and February must be used.

IV.—The table may be used for any other centuries (N.S.), the calendar being repeated every fourth century. Thus 1600–1699 is identical with 2000; 2100 with 1700; 2200 with 1900, &c.

V.—For Old Style dates, in the first motion of the disc, the day of the week given in the following table must be set opposite to the given year; the second motion being the same as in New Style dates:—

Hundreds (Old Style).			Division of Disc.
—	18	11	Sunday
—	17	10	Monday
—	16	9	Tuesday
—	15	8	Wednesday
—	14	7	Thursday
20	13	&c.	Friday
19	12		Saturday

N.B.—That the years 1600, 1700, 1800, &c., are all leap years, O.S.; but only every fourth of them, *e.g.* 1600, 2000, 2400, &c., are leap years according to N.S.

THE MAGIC SQUARE OF FOUR.

To the Editor of KNOWLEDGE.

DEAR SIR,—For the sake of accuracy, I should like to point out a mistake in my estimate of the number of varieties of type D. The types A, B and D are mutually convertible by a few simple transpositions, and therefore must have the same number of varieties. Now it is mathematically demonstrable that there can be only 48 varieties of A and B; hence there must be just 48 of D. How it happened I wrote 96 I do not know.

On the other hand, Mr. Cram tells me he can make 56 each of G, I, J, and L. Consequently, we are still 32 short of Frenicle's total of 880.

T. S. BARRETT.

To the Editor of KNOWLEDGE.

DEAR SIR,—In reading Mr. J. Pentland Smith's very interesting article on "Contrivances for the Cross-Fertilization of Plants," in KNOWLEDGE, Feb. 2, 1891, I have been completely puzzled by the following problem:

In speaking of the case of *Aspidistra elatior*, Mr. Smith, either in his own words or quoting Dr. Wilson, says in effect:—

(I.) There is no access to the pollen until the stigma is fertilized.

(II.) Fertilization cannot be effected until pollen has been deposited on the stigma.

What I want to know is: How is the first flower fertilized, so as to commence the process?

Yours faithfully,
F. J. PROVIS.

Coleford, Gloucester, 16th March 1891.

[Until the decay of the stigma the slugs cannot get to the pollen. One can easily imagine that sooner or later the stigma of the first flower of the season will decay, whether pollenated or not, and that then access can be obtained to the pollen below. Pollenation, that is the resting, and ultimate germination of the pollen on the stigma, precedes fertilization in all Angio-sperms or plants which have their seeds enclosed by the carpels.—J. P. SMITH.]

STELLAR SPECTRA.

BY E. W. MAUNDER, F.R.A.S. (*Assistant superintending the Spectroscopic Department of Greenwich Observatory*).

WHEN the publication of Dr. Elkin's determination of the parallax of Arcturus rendered it probable that we must class this star as one of the most distant of its magnitude, it became clear to me, as I tried to show in the February number of KNOWLEDGE, that it must be of most gigantic size, and must move with most amazing swiftness. But a further point for inquiry also suggested itself. If Arcturus be, as would appear to be the case, the star which actually gives the most light of any we know of at present, then its spectrum should be typical of the largest and hottest stars, whereas it has been customary to regard it as of a markedly lower class.

The subject of the classification of stellar spectra has been occupying special attention of late; it may, therefore, be worth while to see if any further light, however feeble, can be thrown on the matter from the point of view suggested by the magnitude of Arcturus.

The earliest classification of stars was effected by Sir W. Herschel, who grouped them according to their colours; the only arrangement possible at a time when the spectroscope was still undreamed of, but a real step, nevertheless, towards the more delicate discrimination which that instrument renders possible. Fraumhofer, in his endeavours to solve the secret of the spectrum, noted the strongly marked differences between the spectra of different stars, and drew the important conclusion that the dark lines which crossed them were due to something in the stars themselves, and not to any effect of our own atmosphere, or any absorption of light in space. But the first spectroscopic classification of stars was due to Rutherford in America, and Secchi in Europe. The latter, as was inevitable in beginning so new a research, made several alterations from his first scheme; but his final classification divided the stars into "types" of spectrum as follows:—

Type I.—The white and bluish white stars, like Sirius and Vega. The spectra in this type show the four lines of hydrogen intensely dark, broad, and with diffused and shaded edges. Metallic lines are faint and narrow, and not easily seen. The principal stars of Orion form a variety of this type, in which the hydrogen lines are much less marked, and much narrower than in other stars of the first type.

Type II. embraces the yellowish stars, such as our Sun, Arcturus, and Aldebaran. The hydrogen lines are well seen, but narrow and fairly sharp; the entire spectrum is full of well-marked metallic lines, some of which are more pronounced than the lines of hydrogen.

The stars of Type III. are mostly orange in hue; α Orionis and α Herculis are the best examples. The hydrogen lines are faint, or no longer seen; but a succession of dark bands, dark and sharp towards the violet, and shading away into nothingness towards the red, makes this type of spectrum the most strongly marked and the most beautiful of any.

Type IV., the stars of which are mostly red, also shows a banded spectrum, but the bands fade off in the opposite direction to those of Type III.

Secchi further called attention to the existence of a couple of stars showing *bright* lines in their spectra, the forerunners of a fifth type; and, a little later, the discovery by MM. Wolf and Rayet of a curious group of stars in Cygnus added a sixth type.

Secchi's classification was purely an observational one, and it was independent of theoretical considerations as to

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the respective ages in the evolution of a normal star which the different types might represent. For it was naturally felt that there must be growth and development amongst stars as amongst animals and plants. A star must have its birth, its periods of growth, full vigour, and decay, closing in the—

> Last scene of all
> That ends this strange, eventful history,

a dark, cold body, incapable of giving light and heat to other worlds, or of sustaining life upon its own surface. And naturally the attempt was made to connect these different types of spectrum with the various stages of stellar life-history. Zöllner seems to have been the first to suggest that the white stars were the hottest, and that the yellow colour of the stars of the second type showed that they had advanced some way in the process of cooling down. Angström suggested that the shaded bands of the orange stars indicated the formation of compound bodies in their atmospheres, consequent on the lowering of temperature; and Lockyer, a little later, expressed the same views still more definitely. "The hotter the star, the simpler its spectrum," he said; "and the older a star, the more does the free hydrogen disappear from it." Vogel, more recently, being dissatisfied with Secchi's mode of grouping stellar spectra, devised a more elaborate one, the principal change from Secchi's system of Types being that Vogel makes Types III. and IV. varieties of the same Class III. The leading thought in this new classification was that all stars have at one time or another been of the first or Sirian Type, all will pass through the second or Solar Type; but after passing this stage the star may either show a spectrum like that of α Herculis, or like that of the small red stars. The road diverges here; the majority follow the path which Antares, Betelgeuse, and the *lucida* of Hercules have taken; but a few, especially the stars in two small groups on the Milky Way, prefer to give spectra in which the bands are sharpest to the red, and shade off towards the violet.

It was well objected to this scheme that it made no provision for a period of increasing temperature in a star. Stars are certainly not brought forth from nebulæ, like Pallas Athene from Jupiter, fully developed and equipped with their whole armoury of light and heat. There is evidently a time during which the surface brilliancy increases, and this probably corresponds with a time during which the mean temperature must be increasing. Besides, the place assigned to the red stars was a perfectly arbitrary one. We know that the First and Second Types are contiguous stages, whichever be the earlier; for stars like Procyon, Rigel, Spica, Polaris, α Cygni, and others, supply examples of almost every possible gradation, from the unmistakable Sirian to the complete Solar form. So, again, Aldebaran, Betelgeuse, and many others form a series of links connecting the Second and Third Types; but until recently the Fourth Type stood alone. There are no instances of stars whose spectra leave us in doubt as to whether the Fourth Type or some other is the more strongly represented; there are no intermediate forms. It is therefore a pure assumption to assert that this particular kind of spectrum is either the next stage to the Solar Type or that it is an alternative stage to the α Herculis Type.

The most recent classification is that of Lockyer, and he certainly avoids one of the objections to which Vogel's is open. The Sirian Type is still taken as that of the hottest stars, but he breaks up the Solar Type into two groups; the one showing rising, and the other falling temperature. The course of evolution, according to his plan, is: Group I., the nebular stage; Group II., the orange star, or α Herculis stage; Group III., the α Cygni stage, including some spectra of Secchi's Type II.; Group IV., the Sirian stage; Group V., the Solar stage, including the rest of Secchi's Type II. stars; Group VI., the red star stage; Group VII., the dark stage. The position assigned to the red stars is, of course, as much a matter of assumption on Lockyer's plan as on Vogel's. The former has, however, this advantage over his predecessors, in that it corresponds to the probable stages of growth as well as those of decay. The Sirian stars, which he, in common with almost every theorist,* regards as the hottest and largest, mark not only the commencement of a fall in temperature, but the conclusion of a rise. We are saved the difficulty of assuming the Sirian phase to be that in which all stars were originally created, and from which they have only changed by degradation.

But in all these systems the supremacy of the Sirian Type is assumed, not proved, and it has been well pointed out that it is quite possible to read the record the other way, and to argue that the ruddy stars are the hottest, and that the orange, yellow, and bluish tints are evidences of a progressive decline in temperature. It is a question, therefore, of much importance to see if any positive information can be given us on the subject.

Two circumstances have greatly operated to the present view. Firstly, that a solid body raised to incandescence first glows with a ruddy hue, and then, as the temperature increases, so the colour changes to orange, yellow, white, or blue; and it was very natural, though scarcely scientific, to extend the analogy to the stars. For a stellar spectrum shows us by the continuous band of colour, interrupted by dark bands, that the light we receive is not the whole of the light the star emits, but that it has suffered absorption in the atmosphere of the star itself; and it is in the differences of the quality and amount of this absorption, and not in the differences of the original light of the star, that we find the tests for distinguishing one type from another. That is to say, it is by the dark lines or bands, and not by the continuous spectrum, that we classify the stars. The difference, therefore, between the Sirian and Solar stars lies not in their photospheres, but in their absorbing atmospheres. For Sirius such absorption is almost confined to hydrogen, the influence of which is excessively marked; but for the Sun, Arcturus, and their congeners, twenty or thirty elements have impressed the spectrum with the evidences of their presence. Given that two stars of these two Types are at the same distance from us, and that they appear to shine with the same amount of light, surely the star which displays the

* In this, as in other departments of science, the inductive method is the only safe one, and a few observed facts are preferable to any number of theories founded on assumed conditions. The physical connection of the trapezium stars with the Orion nebula, and the stars of the Pleiades cluster with the Pleiades nebula, can hardly be doubted; and if the nebular stage is the first one in a star's history, we have evidence that three different classes of spectra are exhibited by stars involved in nebulous matter. In all three the hydrogen lines, or some of them, are conspicuous, but the spectra are considerably more complicated than those of stars usually ranked as belonging to Secchi's First Type. The spectra of the trapezium stars appear to be crossed with bright lines similar to, but more intense than, the bright lines of the Orion nebula around them; the hydrogen lines are not hazy and diffused as in Secchi's First Type, but comparatively narrow and sharp. The two classes of spectra in the Pleiades group each include stars of various magnitudes; and if we may assume that all the stars of the Pleiades group are of the same age, we must conclude that the two classes of spectra do not correspond to different stages of cooling. The star which appeared in the Andromeda nebula in 1885 seems to have had a spectrum terminating abruptly at the red end, as well as, according to some observers, very faint bright lines, which are asserted to exist in the Andromeda nebula spectrum. The facts brought together by Mr. Maunder in this paper should check too precipitate theorists.—A. C. Ranyard.

greatest indications of absorption in its spectrum must be actually emitting the greatest amount of light from its photosphere.* And, to say the least, it is arguable that the fuller development of the metallic spectra in stars of the Second Type shows a higher temperature, not a lower one. It is conceivable, not to put it more strongly, that an intenser heat may in these stars keep metals in the state of absorbing gas, and at a higher atmospheric level, which in Sirian stars are precipitated at or below the photosphere, and so give no sign of their presence. At all events, we can feel well assured that the temperature of the Solar stars is very high, for not only do we find the metallic lines in the visible spectrum, but we find them strongly marked and numerous far in the ultra-violet, a proof that even in the reversing layer the temperature is high enough to compel the metals whose gases compose it to give out radiations of even the shortest wave-lengths, and to give them out strongly and unmistakably.

The other circumstance that has led to the belief that the white stars are the hottest, the red the coolest, is that whilst more than half the stellar giants are of the first type, there are only two 1st-magnitude stars of the third type, and the brightest of the fourth-type stars is not so bright as the 5th-magnitude. But, again, a closer consideration of the facts leads us to a different conclusion. Surely we have no right to assume that the stars are equally distributed amongst the various Types. If they really mark different stages in stellar evolution, some may be much more quickly passed than others; or it may be that but few stars are yet old enough to have reached the most advanced stage, or else that but few are so young as not to have passed through at least one phase. There is, however, a simple test which we can apply. If the orange or ruddy stars are fainter on the average than the white and yellow, then the further down in brightness we go the larger will be the proportion of such stars observed. But this does not appear to be the case. If we take those stars of the Oxford Uranometria which are above the 5th magnitude, and have been classified by Secchi, we find them thus divided :—

		Type I.	Type II.	Type III.
Above	1st mag.	5	2	1
Between	1st and 2nd ...	11	4	1
,,	2nd and 3rd ...	20	17	4
,,	3rd and 4th ...	50	54	2
,,	4th and 5th ...	35	29	2
		121	106	10

The stars of Orion and of the Pleiades which have spectra a little differing from the normal type, have nevertheless been included under Type I. Excluding these, and such stars as were outside the general Oxford limit of North Polar Distance (100°), and were only observed on account of their special brightness, we find that for the stars north of 10° S. Dec., and above the 5th magnitude, the numbers would run :—

		Type I.	Type II.	Type III.
Above	1st mag.	2	2	1
Between	1st and 2nd ...	8	4	0
,,	2nd and 3rd ...	18	17	4
,,	3rd and 4th ...	45	54	2
,,	4th and 5th ...	33	29	2
		106	106	9

It would seem then that, within these limits, the first and second types are about equally numerous, and each about twelve times as abundant as the third.

Comparing these numbers with the results of Vogel's and Konkoly's spectroscopic surveys, which were carried down to the 7½ mag., we find that they give out of 6,073 stars examined the numbers for each type as follows :—

Type I.	Type II.	Type III.	Type IV.
3,145	2,105	375	12

besides 14 stars of the Orion variety of Type I. and 422, that could not be properly classified under any of the above heads.

The comparison shows that, so far as these observations go, Type I. has a small preponderance over Type II. for the higher magnitudes, but that this preponderance ceases between the 3rd and 4th magnitudes to become much more marked as fainter stars are included. Three conclusions seem to be fairly deducible from this result. First, that Sirian stars are more numerous on the whole than Solar stars. Secondly, Solar stars are on the average rather brighter than the Sirian stars, or else rather nearer to us. Thirdly, that the average difference in the brightness of the stars of the two Types is not by any means so great as we should expect if either Type marked a stage of very greatly superior temperature to the other.

Of course the materials I have used are very incomplete and can only supply indications, and not proofs. Still, it may be worth while to take the question a stage further, and see what light parallax determinations have to throw on the question.

Taking the table of parallaxes given in the appendix to Miss Clarke's *System of the Stars*—a book as valuable and instructive as it is charming in style—we find 20 stars the parallaxes of which are given, and which are found in Secchi's lists of star Types. Adding Arcturus we have 21, of which nine are First Type, and 12 Second Type stars. Employing the Oxford magnitudes and computing the absolute light-giving power of each star, taking Sirius as our standard, we obtain the following table :—

Sirian Stars.		Solar Stars.	
β Cassiopeiæ	0·29	α Cassiopeiæ	1·41
α Persei	1·96	η Cassiopeiæ	0·12
Sirius	1·00	β Andromedæ	0·98
Procyon	0·56	Polaris	4·45
Regulus	2·55	α Arietis	1·39
α Lyræ	48·35	Aldebaran	1·68
α Draconis	0·04	Capella	5·14
α Aquilæ	0·61	Pollux	3·92
α Cephei	1·60	η Herculis	0·15
		π Herculis	0·19
		ϵ Cygni	0·50
		Arcturus	147·00

It will be seen at once that two stars stand out from all the rest; Vega amongst the Sirian stars being nearly six times as bright as the other eight taken together; and Arcturus, amongst the Solar stars, more than seven times as bright as all the eleven others taken together. In both cases the parallax adopted is that of Dr. Elkin, which for these two stars, and especially for Vega, differs

* If the stars are all composed of similar materials (as has been, perhaps, too hastily assumed), and their photospheres are clouds of incandescent particles. The temperature of their photospheres could not exceed the highest temperature at which the most refractory materials would be driven into vapour, and all photospheres would shine with equal brightness. That there are differences in the apparent brightness, area for area, of stars can hardly be doubted from the facts we have already learnt with regard to the masses of double stars; such, for example, as Sirius and his companion, and the binaries of the Algol type.

From the facts we know with regard to our own sun we cannot suppose that the matter of gaseous stars is stratified at different levels, as some theorists have too hastily assumed. For on the sun the continuous eruption of matter from below the photosphere would sufficiently mix the gaseous matter by transfer in mass, if we could conceive of it as not mixed by diffusion. Any apparent stratification can only be due to some vapours continuing incandescent at lower temperatures than others.—A. C. Ranyard.

considerably from the results obtained by other observers. The mean of seven other fairly accordant determinations of the parallax of Vega would give its intrinsic light-giving power as 1·92. In any case the two stars are evidently exceptional, and, as what we are seeking for is an average result, may well be left on one side, and then the remaining stars do not differ extravagantly in brightness. The mean Sirian star would then have a light-giving power of 1·07; the mean Solar star of 1·8; a result which I think may at least warrant us in saying that the supposed superiority of First Type stars receives no support from it.

Yet another mode of attacking the problem is open to us. Binary stars, the orbits of which have been determined afford a means, as Mr. Monck has pointed out, of forming some idea of their relative brightness, if we assume that all the stars in question are spheres of equal density, and Mr. Gore, in his recent "Catalogue of Binary Stars," has computed this relative brilliancy per unit of surface for most of the fifty-nine stars whose orbits he gives. The result is a curious one. All the stars are, as Mr. Gore himself remarks, either First or Second Type, and there is a well-marked and unmistakable superiority of the First over the Second.* Assuming all the stars of equal density, the Sirian are about six times as bright, surface for surface, as the Solar. From this we may infer that the slight superiority in total radiating power of the Solar stars is not due to greater extent of photosphere in proportion to their mass, but that the very reverse is the case; so that the Solar stars do not merely emit more light than the Sirian, but they are superior to them in a yet higher proportion, both in size and density. If so, we may regard theorists as probably right when they have placed the Second Type stars as belonging to a later stage that the First; but as wrong when they have regarded the Sirian stars as occupying the apex of the curve, and stars like our sun as being well advanced on the road to decay.

* Except in the case of one star, γ Leonis, which is clearly by far the brightest star, surface for surface, on the assumption mentioned above.

A PERPETUAL CALENDAR.

In addition to the rules given in the last number for finding the day of the week corresponding to any given date New Style, we might have added some simple rules to extend the use of Mr. Prince's table and calendar to dates previous to 2nd September 1752, when the Old Style of reckoning came to an end. The change of style was effected in England by dropping the eleven days between Wednesday the 2nd September 1752, and Thursday the 14th September 1752. If the eleven days had not been dropped, the 14th of September would have been on a Monday; therefore, in passing backwards from New Style dates to Old Style dates, Thursday becomes Monday and one jumps forward four days in the week, or backwards three days.

To find the day of the week on which an event happened in the last century after the change of style, the rule given in the last number was—find the day of the week for the corresponding day in this century, and go forward two days in the week. From the beginning of the century to the 2nd September 1752, you must find the day of the week for the corresponding day in this century and go forward six days, which is equivalent to going back one day in the week.

Events which happened in the 17th century occurred on the same day of the week as that on which the bicentenary of the event falls in this century; thus, Evelyn mentions that Ash Wednesday in the year 1661 was on February 27th. Turning to the table in the last number, we find that the Dominical Letter for 1861 was F, and that the 27th February 1861 was also on a Wednesday. To go back to preceding centuries of Old Style reckoning we go forward one day in the week for every century. Thus, events in the 16th century which happened on a Sunday, have their tercentenaries in this century on a Saturday.

Mr. E. Erskine Scott has sent us a Perpetual Almanack and Calendar published by him in 1850, which, besides a table for finding the day of the week corresponding to any day of the year when the Dominical Letter is given, gives a table with the Dominical Letter for every year, from the Christian Era onwards, reckoning by either Old Style or New—a table which will be found convenient for determining the days of the week corresponding to dates in foreign countries as well as in England. The Gregorian or New Style was adopted in Rome in 1582; in Paris, by taking ten days off the Calendar, 15th December 1582. In Russia, Old Style is still in use. It now differs from the New Style by twelve days; thus, the 13th of April 1891 in England corresponds to the 1st of April in Russia.

TABLE I.

Mr. Erskine Scott's Table for finding the Dominical Letter or Letters for any Year, Old Style or New.

New Style. Hunds. of Years.				Years above Hundreds.				Old Style. Hundreds of Years.						
100	200	300	400					...	100	200	300	400	500	600
500	600	700	800					700	800	900	1000	1100	1200	1300
900	1000	1100	1200					1400	1500	1600	1700	1800	1900	2000
1300	1400	1500	1600					2100	2200	2300	2400	2500	2600	2700
1700	1800	1900	2000					DC	ED	FE	GF	AG	BA	CB
2100	2200	2300	2400					B	C	D	E	F	G	A
C	E	G	BA					A	B	C	D	E	F	G
B	D	F	G	1	29	57	85	G	A	B	C	D	E	F
A	C	E	F	2	30	58	86	FE	GF	AG	BA	CB	DC	ED
G	B	D	E	3	31	59	87	D	E	F	G	A	B	C
FE	AG	CB	DC	4	32	60	88	C	D	E	F	G	A	B
D	F	A	B	5	33	61	89	B	C	D	E	F	G	A
C	E	G	A	6	34	62	90	AG	BA	CB	DC	ED	FE	GF
B	D	F	G	7	35	63	91	F	G	A	B	C	D	E
AG	CB	ED	FE	8	36	64	92	E	F	G	A	B	C	D
F	A	C	D	9	37	65	93	D	E	F	G	A	B	C
E	G	B	C	10	38	66	94	CB	DC	ED	FE	GF	AG	BA
D	F	A	B	11	39	67	95	A	B	C	D	E	F	G
CB	ED	GF	AG	12	40	68	96	G	A	B	C	D	E	F
A	C	E	F	13	41	69	97	F	G	A	B	C	D	E
G	B	D	E	14	42	70	98	ED	FE	GF	AG	BA	CB	DC
F	A	C	D	15	43	71	99	C	D	E	F	G	A	B
ED	GF	BA	CB	16	44	72	...	B	C	D	E	F	G	A
C	E	G	A	17	45	73	...	A	B	C	D	E	F	G
B	D	F	G	18	46	74	...	GF	AG	BA	CB	DC	ED	FE
A	C	E	F	19	47	75	...	E	F	G	A	B	C	D
GF	BA	DC	ED	20	48	76	...	D	E	F	G	A	B	C
E	G	B	C	21	49	77	...	C	D	E	F	G	A	B
D	F	A	B	22	50	78	...	BA	CB	DC	ED	FE	GF	AG
C	E	G	A	23	51	79	...	G	A	B	C	D	E	F
BA	DC	FE	GF	24	52	80	...	F	G	A	B	C	D	E
G	B	D	E	25	53	81	...	E	F	G	A	B	C	D
F	A	C	D	26	54	82	...	DC	ED	FE	GF	AG	BA	CB
E	G	B	C	27	55	83	...							
DC	FE	AG	BA	28	56	84	...							

Directions.—Look for the hundreds contained in the given year at the top of the Table, on the left for New

Style, and on the right for Old Style; then below this point, and on a line with the given year of the century in the centre of the Table, you will find the Dominical Letter for the year.

TABLE II.

For Finding the Days of the Week corresponding to the Days of the Months; the Dominical Letter for the Year being ascertained by Table I.

Note.—*The double letters in each compartment refer to leap years, the single to common years.*

JANUARY	A	AG	B	BA	C	CB	D	DC	E	ED	F	FE	G	GF
FEBRUARY	D	DC	E	ED	F	FE	G	GF	A	AG	B	BA	C	CB
MARCH	D	ED	E	FE	F	GF	G	AG	A	BA	B	CB	C	DC
APRIL	G	AG	A	BA	B	CB	C	DC	D	ED	E	FE	F	GF
MAY	B	CB	C	DC	D	ED	E	FE	F	GF	G	AG	A	BA
JUNE	E	FE	F	GF	G	AG	A	BA	B	CB	C	DC	D	ED
JULY	G	AG	A	BA	B	CB	C	DC	D	ED	E	FE	F	GF
AUGUST	C	DC	D	ED	E	FE	F	GF	G	AG	A	BA	B	CB
SEPTEMBER	F	GF	G	AG	A	BA	B	CB	C	DC	D	ED	E	FE
OCTOBER	A	BA	B	CB	C	DC	D	ED	E	FE	F	GF	G	AG
NOVEMBER	D	ED	E	FE	F	GF	G	AG	A	BA	B	CB	C	DC
DECEMBER	F	GF	G	AG	A	BA	B	CB	C	DC	D	ED	E	FE

1	8	15	22	29	Sun.	Sat.	Fri.	Thur.	Wed.	Tues.	Mon.
2	9	16	23	30	Mon.	Sun.	Sat.	Fri.	Thur.	Wed.	Tues.
3	10	17	24	31	Tues.	Mon.	Sun.	Sat.	Fri.	Thur.	Wed.
4	11	18	25	...	Wed.	Tues.	Mon.	Sun.	Sat.	Fri.	Thur.
5	12	19	26	...	Thur.	Wed.	Tues.	Mon.	Sun.	Sat.	Fri.
6	13	20	27	...	Fri.	Thur.	Wed.	Tues.	Mon.	Sun.	Sat.
7	14	21	28	...	Sat.	Fri.	Thur.	Wed.	Tues.	Mon.	Sun.

Directions.—The Dominical Letter answering to the given year being found by Table I., find this Dominical Letter in the above Table on the same horizontal line with the given month, and under it, in the lower part of the Table, are the days of the week, corresponding with the days of the given month in the same horizontal line on the left-hand side of the Table.

ERRATUM.

In the Article on the Milky Way in the Southern Hemisphere, in the last number of Knowledge, it was by mistake stated that one of the two clusters at the bottom of Mr. Barnard's plate of the Sagittarius Region of the Milky Way was entirely wanting in Mr. Russell's photographs. This is not the case, though there is ample evidence of the variation in brightness of many other stars shown upon the plates. Only one of the clusters is shown in the plate from Mr. Russell's photograph; the other, or preceding cluster, is just outside the field.

OUR INVISIBLE FOES, OR BACTERIA IN AGRICULTURE.

By Miss A. W. Buckland.

THE first question now asked whenever an epidemic attacks either man or the lower animals is, Is it caused by germs or *bacilli* floating in the air, or conveyed by water, milk, or any other medium. The germ theory of disease, at present so popular, may be said to have originated in the successful experiments made by M. Pasteur for the cure of the dreadful disease known as splenic fever in sheep, and the importance of the subject to the agriculturist and merchant, as well as to the medical profession, may be best understood and appreciated by reference to a few facts.

During the year 1888 more than eleven hundred head of cattle were slaughtered in Dublin, because they had been in contact with a few suffering from pleuro-pneumonia, whilst the Commission appointed to investigate the best mode of preventing and curing this and similar diseases, recommended the continuous slaughter of all animals which might have been exposed to infection, adding to the report, however, a clause to the effect that, should experiments in inoculation be deemed advisable, such experiments should be carried out only with the most stringent precautions.

Meanwhile the Government of India, as the result of experiments made, has ordered the inoculation of all the valuable elephants in the Government stables, for the prevention of a disease by which they have hitherto been decimated. M. Pasteur, as is well known, proposed to exterminate the millions of rabbits which have become such a pest in Australia and New Zealand, by introducing among them by inoculation the disease known as chicken-cholera, deadly to fowls and rabbits, but harmless to other animals and to man. But although the Australasian Governments approached the matter in a scientific spirit, and gave every facility for properly conducted experiments, under the supervision of Dr. Katz, bacteriologist, employed by the Linnean Society,—(1) to test the communicability of chicken-cholera to rabbits, the possibility of spreading the disease from rabbit to rabbit, and the readiness and channels by which such communication could be procured; (2) to ascertain whether the disease is transmissible from infected rabbits to other domestic animals—mammals and birds; (3) to ascertain whether the infectivity of the disease is weakened by repeated transmissions from rabbit to rabbit,—the experiments do not appear to have been successful, for although the rabbits inoculated die, they do not apparently convey the disease to others. Nevertheless it seems to be demonstrated beyond dispute, that certain forms of bacteria invariably accompany certain diseases, and reproduce similar diseases when introduced by inoculation into the bodies of men or animals.

These *micro-organisms*, so exceedingly small as to be absolutely invisible to the naked eye, have yet been so carefully observed microscopically, and so faithfully reproduced and enlarged by photography, that they can be studied in all their wonderfully varied forms; and the differences between them are sufficiently marked to be appreciated even by the non-scientific observer. Some resemble dots in various groups; some are twisted spirals; some look like chains; others resemble small bags, with strings attached; some look like branches of trees, whilst others are simply rods crossing each other.

If we regard them as animals, they do not appear to possess any bodily parts, neither head nor tail, neither heart nor stomach; whilst if they are vegetables, they have neither roots nor branches, although abounding in spores. That they are very much alive cannot be doubted, nor the fact that they multiply with the most astonishing rapidity. The growth of one which occurs in sugar is so rapid that 49 hectolitres of molasses were converted into a gelatinous mass in twelve hours.

Micro-organisms can be cultivated in various media, and will still retain their identity, but they cannot all be cultivated in the same media. Dr. Crookshank says: "Some species cannot be cultivated artificially, others will only grow upon blood-serum; many grow upon nutrient gelatine, but some species only if it be acid or alkaline

respectively. Though the comma bacillus of Koch, like the majority of organisms, grows best on an alkaline medium, yet the surface of a potato is acid, and on this it is well known to flourish at the temperature of the blood."

These bacteria are everywhere, in the air we breathe, in the water we drink, in the ground we tread on, but happily some are innocuous; and the noxious must find a suitable soil in which to develop their evil nature, otherwise the human race must have been exterminated by them long ago, and the whole of the animal and vegetable world must have become simply putrefactive media for the propagation of micro-organisms. We cannot pretend in this article to go into any scientific description of the numerous bacteria which, thanks to the researches of Koch, Pasteur, and many other zealous workers on the Continent, have become as well known as creatures of larger growth; but we will endeavour to point out some of the points of interest to the general public in this new science, as brought before us in the *Manual of Bacteriology* of Dr. Crooksbank, one of our chief English workers in this branch of science, who established a bacteriological laboratory at King's College, in which many elaborate investigations are carried on daily. His *Manual* is primarily for the use of students, and therefore deals largely with the methods of cultivation, and preparation for the microscope, of the various species of bacteria, all the necessary apparatus being elaborately illustrated.

The study of bacteria may be considered to be quite recent, yet, as Dr. Crookshank points out, "Leeuwenhoeck, two hundred years ago, recognised and described microscopic organisms in putrid water and saliva, which probably correspond with organisms such as vibrios and leptothrix of modern times." The article upon "Medicine" in the *Encyclopædia Britannica* also points out that Schönlein "made in 1839 one discovery apparently small, but in reality most suggestive, namely, that the contagious disease of the head called *favus* is produced by the growth in the hair of a parasitic fungus." In this may be found the germ of the startling modern discoveries in parasitic diseases; and it seems that even as early as 1773 Müller suggested a classification of these microscopic organisms; but even to the present day their exact place in the economy of nature has not been determined. "Existing as they do," says Dr. Crookshank, "upon the very borderland of the vegetable and animal kingdoms, not only have they been transferred from one to the other, but even the question has been raised whether the smaller forms should be considered as living beings at all." But he says: "The gradual improvements in the means of studying such minute objects, the methods of cultivating them artificially, and of studying their chemistry and physiology, and the ever-increasing revelations of the microscope, have resulted in establishing these microscopic objects as members of the vegetable kingdom, ranking among the lowest forms of fungi."

After showing the various classifications of these fission-fungi, Dr. Crookshank divides them, after Zopf, into four groups, and each group again into genera and species. He then gives a long list of each, classifying them according to their association with disease in man and animals, and adding to the list such as are unassociated with disease. Glancing at these lists, we are struck by the fact that in some of the groups almost all the species are associated with disease, whilst some forms are common to men and animals. In *Streptococcus*, for instance, there are seventeen species traceable to disease in man, eleven belonging to disease in animals, two common to animals and man, and only four unassociated with disease. In *Sarcina*, on the contrary, all the species appear to be innocuous. In other groups the hurtful and innocent species are more equally divided. In the genus *Micrococcus*, to which belongs the much-dreaded germ of rabies, and also that of scarlatina, measles, and whooping-cough, there are ten species belonging to human disease, five to animals, one to plants, and eighteen which are harmless. In the Bacteriaceæ the hurtful and innocent species seem also to be pretty equally divided; but to this group belong some of the most dreaded of disease-germs, such as that of pneumonia, diphtheria, chicken-cholera, the disputed comma bacillus of Asiatic cholera, the bacilli associated with typhus fever, with anthrax, with tuberculosis, with malaria, with swine fever, &c. &c.

The yeast-fungi and mould-fungi, some of which are so destructive to vegetable life, appear to be allied to the bacteria or fission-fungi, but are nevertheless quite distinct. The moulds of various kinds, which form on almost everything eatable, especially in damp weather, belong to these, but they also include the potato-blight (*Peronospora infestans*), grape-disease (*Oidium*), the mildew, smut, and other wheat-diseases, the salmon-fungus, and the silkworm disease; all of which have had disastrous effects upon the prosperity of mankind, although they have not been inimical to human life in the same way as the Bacteria.

It would seem as though these micro-organisms were Nature's favoured weapons of destruction—her tiny poisoned arrows, with which she shoots hither and thither continuously, and against which all living things, whether animal or vegetable, require to be rendered more invulnerable than Achilles. Is there to be found any Styx wherein mankind *may* be rendered invulnerable to the attacks of these invisible foes? Pasteur is supposed to have discovered the means of depriving some of these arrows of their deadly power by extending to other diseases the system of inoculation, introduced first in connection with small-pox, and afterwards modified by Jenner into vaccination, long before the discovery of Bacteria as the constant accompaniment, if not the actual source, of disease.

The two diseases, with the cure or prevention of which the name of Pasteur will be always associated, are rabies or hydrophobia, and anthrax, known also as splenic fever or wool-sorter's disease; the former is, without doubt, one of the most terrible of maladies, and the latter, although less generally known, has caused the cruel death of multitudes who have been brought into contact with it. Both diseases are communicated in the first place from animals to man. The mode of prevention adopted by M. Pasteur is inoculation with the bacillus of the disease, thus resembling the old inoculation for small-pox rather than vaccination, which is the communication of an allied animal disease rather than the human form of that disease. But M. Pasteur does not, as in the old inoculation, give the disease in its full force; but he takes the bacillus, cultivates it in different media, and only introduces it into the animal or human body after it has been attenuated and its full malignity destroyed.

Speaking of anthrax, Dr. Crookshank says: "By cultivating the bacillus in neutralized bouillon at 42°–43° C. for about twenty days, the infecting power is weakened, and animals inoculated with it are protected against the disease." To obtain a still more perfect immunity, they are inoculated a second time with material which has been less weakened. The animals are then protected against the most virulent anthrax, but *only for a time*. From such a culture, however, new cultures of virulent bacilli can be started, and a culture that is "vaccin" for

sheep, kills a guinea-pig, and then yields bacilli that are fatal to sheep. Exposure to a temperature of 55° C., or treatment with ·5 to 1 per cent. carbolic acid, deprives the bacilli of their virulence. The virulence of the bacillus is also altered by passing the bacillus through different species of animals. The bacillus of sheep or cattle is fatal when re-inoculated into sheep or cattle; but, if inoculated in mice, the bacilli then obtained lose their virulence for sheep or cattle; only a transitory illness results, and the animals are protected for a time against virulent anthrax. The possibility of mitigating the virus depends upon the species of animal; rodents cannot be rendered immune by any known "vaccin." The same process is employed by M. Pasteur in his now celebrated inoculations for hydrophobia. In the course of his experiments some very curious facts have come to light; it has been discovered that "passing the virus through various animals considerably modifies its properties. By inoculating a monkey from a rabid dog, and then passing the virus through other monkeys, the virulence is diminished; but by inoculating a rabbit from the dog, and passing the virus from rabbit to rabbit, the virulence is increased." In swine-erysipelas Pasteur and Thuillier discovered that "by passing the virus through pigeons the virulence was increased, but by passing it through rabbits it was progressively diminished. Thus a virus was obtained from a rabbit, which produced only a mild disease in pigs, and after recovery complete immunity."

To the non-professional observer, these facts seem pregnant with deep meaning; they appear to point to the change from the old inoculation for small-pox to the vaccination of Jenner, in which a similar but less virulent disease may be communicated from a lower animal to man, producing immunity from the graver disease; and as we look down the long lists of bacilli, some of deadly virulence and some innocuous, yet all belonging to the same group of germs, we wonder whether eventually it may not be found that a cultivation of innocent germs may be made to supplant the more malignant forms; and this opens up the whole question of immunity, which forms one of the most interesting portions of Dr. Crookshank's book.

Immunity may be natural or acquired. We all know that certain individuals are much more subject to infectious diseases than others, even of the same family. In some diseases one attack renders the person impervious to the same disease; but this is not always the case, sometimes after a time the protective influence of the first attack ceases, and the individual succumbs to the disease a second time. In certain diseases one attack predisposes to a recurrence of the disease, as for example erysipelas; and again, "the occurrence of one disease is stated to induce a liability to others; small-pox and typhoid fever are regarded as predisposing to tuberculosis." When Pasteur first began to try to mitigate the virulence of anthrax, he found that by cultivating the microbe in chicken broth, and allowing it to remain for several months before carrying on successive cultivations in fresh media, "the new generations which were then obtained were found to have diminished in virulence, and ultimately a virus was obtained which produced only a slight disorder; and on recovery the animal was found to be proof against inoculation by virulent matter." This change in the quality of the virus M. Pasteur attributed to a prolonged contact with the oxygen of the air, and he shows that if the cultivation of these germs is carried on in sealed tubes, admitting very little air, the virulence is retained. Heat also has been found to diminish the virulence of the bacillus of anthrax, and the same has been brought about by chemical means, carbolic acid in minute quantities, and bichromate of potash added to a cultivation, "gave after three days a new growth, which killed rabbits, guinea-pigs, and half the sheep inoculated; after ten days rabbits and guinea-pigs, but not sheep; and after a longer time even guinea-pigs were unaffected."

In discussing the question of what constitutes immunity, Dr. Crookshank gives some very curious and suggestive facts. He says: "Raulin has shown that *Aspergillus niger* develops a substance which is prejudicial to its own growth in the absence of iron salts in the nutrient soil. Pasteur has suggested that in rabies, side by side with the living and organized substance, there is some other substance which has, as in Raulin's experiment, the power of arresting the growth of the first substance. If we accept the theory of arrest by some chemical substance, we must suppose that in the acquired immunity afforded by one attack of an infectious disease this chemical substance is secreted, and, remaining in the system, opposes the onset of the micro-organism at a future time. In the natural immunity of certain species and individuals we must suppose that this chemical substance is normally present."

Passing over two other theories, each of which presents certain difficulties, we find the curious fact that in some cases the white blood-cells appear to have the singular power of destroying bacteria. "If anthrax bacilli are inoculated in the frog, the white blood-cells (leucocytes) are observed to incorporate and destroy them until they entirely disappear, and the animal is not affected. But if the animal, after inoculation, is kept at a high temperature, the bacilli increase so rapidly that they gain the upper hand over the leucocytes, and the animal succumbs. In septicæmia of mice the white blood-cells are attacked and disintegrated by the bacilli in a similar way. It is, however," adds Dr. Crookshank, "difficult to accept any explanation of immunity from these observations—to suppose, for example, that immunity depends upon the micro-organisms being unable to cope with the leucocytes in certain species. It is difficult to conceive that the leucocytes in the blood and tissues in the field-mouse are differently constituted from those in the house-mouse, so that they form an effectual barrier in the one case, though so readily destroyed in the other." Hence we understand that field-mice are exempt from the septicæmia which is fatal to house-mice and sparrows, the representative bacilli of the disease being found most commonly in the interior of the white blood-corpuscles. Perhaps the immunity of field-mice may result from some chemical secretion or the difference in their mode of life and in their food. This is a subject still open to investigation.

In anthrax "a drop of blood from an affected animal, or a minute portion of a cultivation, introduced under the skin of a mouse or guinea-pig, causes its death, as a rule, in from twenty-four to forty-eight hours. Sheep fed upon potatoes which have been the medium for cultivating the bacillus, die in a few days. Goats, hedgehogs, sparrows, cows, horses are all susceptible. Rats are infected with difficulty. Pigs, dogs, cats, white rats, and Algerian sheep have an immunity from the disease. Frogs and fish have been rendered susceptible by raising the temperature of the water in which they lived." In this list we find the same difference with regard to sheep as in the two species of mice. To the common sheep the disease is fatal, whilst the Algerian sheep is immune. This immunity of certain species has been seized upon by agriculturists, who, when their flocks and herds suffer from a certain disease, have found it beneficial to change the breed. At the Cape of Good Hope, for instance, many

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years ago, when the Angora goat was introduced, it was found to be less liable to scab than the common goat. The same thing has followed from great blights in the vegetable world. The disastrous potato-blight caused the introduction of many new varieties found by experience to be capable of resisting the disease; and the European vines affected by phylloxera are now being replaced by different kinds brought from America and other parts of the world. There can be no doubt that in time this immunity will cease, and the newly introduced variety will require to be again replaced, unless some means should be found of destroying the micro-organisms, which, like the newly introduced animals or vegetables, will in time adapt themselves to their surroundings, and perhaps acquire fresh virulence thereby.

When the investigations into disease-germs began, it was thought by many that all infective diseases might be prevented by inoculation, but at present the various experiments made have not confirmed this idea except in anthrax, or splenic fever, rabies, and the new remedy for tuberculosis*; it seems, however, probable that some day pleuro-pneumonia may be added to the list. For many years past this disease has been successfully treated at the Cape of Good Hope, and in Australia, by inoculation.

Happily, it seems that the wide-spread infection, which at one time was supposed to be likely to follow the burial of an infected animal through earth-worms bringing the bacilli to the surface, is not so common as was believed. "Klein has pointed out that if mice and guinea-pigs which have died of anthrax are kept unopened, the bacilli simply degenerate and ultimately disappear"; therefore Dr. Crookshank thinks that free access to oxygen is necessary to develop the spores. "Contamination of ground in which diseased animals have been buried must result, therefore, from bodies in which a post-mortem examination has been made, by which the blood and organs have been freely exposed to the air, or from animals which have not been examined, owing to their hides being soiled with excretions, and with blood which issues from the mouth and nostrils before death."

One of the most prominent uses of the science of bacteriology is the power gained by it of examining the water, air, and soil of any place, and thus determining the number and character of the bacteria in any given spot. By this means, places particularly subject to any given disease may be avoided by those peculiarly liable to such disease, and it may be, also, that eventually a means may be found of destroying the pestilential bacilli, and rendering spots formerly unhealthy fit for human habitation.

Before concluding this paper, we ought to point out the numbers of bacteria which have been observed to be present in the air at different times and places. Miquel, who has made this a special study, finds "the average number per cubic metre of air for the autumn quarter at Montsouris to be 142, winter quarter 49, spring quarter 85, and summer quarter 105. In air collected 2,000 to 4,000 metres above sea-level, not a single bacterium or fungus spore was furnished; while in ten cubic metres of air from the Rue de Rivoli (Paris), the number was computed at 55,000. By an apparatus known as 'Hesse's,' twenty-five litres of air from an open square in Berlin, gave rise to three colonies of bacteria and sixteen moulds; whilst two litres from a schoolroom just vacated by the scholars, gave thirty-seven colonies of bacteria and thirty-three moulds." The wonder is that with all these sources of disease and death constantly with us, anyone should escape; nevertheless, it is an established fact that none of these micro-organisms are ever found in perfectly healthy blood. The reason of this is not plain. It is certain that the healthy and unhealthy alike must inhale or swallow these germs; why should they be deadly to the one and innocuous to the other? Is it because in health the white corpuscles of the blood are in such a state of chemical activity as to be able to absorb and consume these micro-organisms, as in the recorded case of the frog? And is it, as in the same case, only when the temperature becomes raised by fever, that the germs develop too rapidly for natural elimination? This would appear a possible explanation, but more is wanted. Why, if these germs are everywhere, should we not more frequently hear of the spontaneous outbreak of disease, instead of finding it generally traceable to one especial source?

* Dr. Koch's inoculation differs from that of Pasteur in the injection of dead instead of living bacilli.

THE FACE OF THE SKY FOR APRIL.

By Herbert Sadler, F.R.A.S.

THE number of sun-spots and faculæ on the solar disc continues steadily to increase. The zodiacal light should be looked for during the first ten days of the month. Conveniently observable minima of Algol occur at 7h. 14m. P.M. on the 4th; 0h. 7m. A.M. on the 22nd; and 8h. 56m P.M. on the 24th. The following are the times of minima of some of the Algol type variables alluded to by Miss Clerke in the March number of Knowledge, and which may be conveniently observed at the present time. The places are for 1890.

U Cephei (0h. 52m. 32s. +81° 17′). Max. 7·1 mag.; min. 9·2 mag. Period, 2d. 11h. 49m. 45s. April 14th, 1h. 53m. A.M.; April 19th, 1h. 32m. A.M.; April 24th, 1h. 12m. A.M.; April 29th, 0h. 52m. A.M.

R Canis Maj. (7h. 14m. 30s. −16° 11′). Max. 5·9 mag.; min. 6·7 mag. Period, 1d. 3h. 15m. 55s. April 2nd, 6h. 49m. P.M.; April 3rd, 10h. 5m. P.M.; April 19th, 7h. 46m. P.M.; April 28th, 9h. 52m. P.M.

S Cancri (8h. 37m. 39s. +19° 26′). Max. 8·2 mag.; min. 9·8 mag. Period, 9d. 11h. 37m. 45s. April 19th, 0h. 36m. A.M.

δ Libræ (14h. 55m. 6s. −8° 5′). Max. 5·0 mag.; min. 6·2 mag. Period, 2d. 7h. 51m. 23s. April 2nd, 8h. 53m. P.M.; April 9th, 8h. 28m. P.M.; April 16th, 8h. 1m. P.M.; April 23rd, 7h. 36m. P.M.; April 30th, 7h. 12m. P.M.

U Coronæ (15h. 13m. 43s. +32° 3′). Max. 7·5 mag.; min. 8·9 mag. Period, 3d. 10h. 51m. 8½s. April 6th, 1h. 5m. A.M.; April 12th, 10h. 47m. P.M.; April 19th, 8h. 29m. P.M.

A maximum of S Coronæ (6·1 mag. − 7·8 mag. at max.; 11·9 mag. − 12·5 mag. at min.), which follows U Coronæ 3m. 12s. in R.A., and is 17′·3 south of it, is due on April 5th.

Mercury is very well placed for observation during the greater part of April. On the 1st he sets at 7h. 22m. P.M., or 52m. after the sun, with an apparent diameter of 5½″ and a northern declination of 8° 2′. At this time he will appear about as bright as Aldebaran, about $\frac{193}{1000}$ of the disc being illuminated. He gradually increases in brightness, setting on the 7th at 8h. 9m. P.M., 1h. 29m. after the sun, with an apparent diameter of 6″, and a northern declination of 13° 20′. At this time he is considerably brighter than an average first magnitude star in the same position, rather less than eight-tenths of the disc being illuminated. On the 11th he sets at 8h. 37m. P.M., 1h. 50m. after the sun, with an apparent diameter of 6½″, and a

northern declination of 16° 18′. His theoretical brightness is now about equal to what it was on the 1st, but, owing to his being considerably farther from the sun, he will probably appear brighter. About $\frac{64}{100}$ of the disc is now in sunlight. On the 17th he sets at 9h. 3m. P.M., 2h. 6m. after the sun, with an apparent diameter of $7\frac{1}{2}''$, and a northern declination of 19° 28′. He is at his greatest eastern elongation (19° 50′) at 7h. P.M. on the 18th. On the 21st he sets at 9h. 10m. P.M., 2h. 7m. after the sun, with an apparent diameter of 8·4″, and a northern declination of 20° 40′. He has now decreased very perceptibly in brightness, about three-tenths of the disc being illuminated. On the 27th he sets at 9h. 1m. P.M., 1h. 46m. after the sun, with an apparent diameter of $9\frac{3}{4}''$, and a northern declination of 21° 5′. He now does not exceed a 5th magnitude star in brightness, about $\frac{15}{100}$ of the disc being illuminated. During the month Mercury passes through Pisces on to the borders of Aries and Taurus, being found at the end of the month near the group ζ, τ, 63 and 65 Arietis, but without approaching any conspicuous star very nearly.

Venus is a morning star throughout the month, but is too near the sun to be well seen. On the first she rises at 4h. 27m. A.M., 1h. 11m. before the sun, with an apparent diameter of 16·0″, and a southern declination of 11° 36′, She is near Jupiter on the mornings of the 7th and 8th. On the 30th she rises at 3h. 39m. A.M., 57m. before the sun, with an apparent diameter of $13\frac{1}{2}''$, and a southern declination of 0° 2′. About seven-tenths of the disc is illuminated on the 1st of April, and nearly eight-tenths on the 30th, when the theoretical brightness of the planet is only one-third of what it was at the beginning of January. On the morning of the 15th Venus will be very near the 4th magnitude star ϕ Aquarii. During the month she moves from Capricornus through the greater part of Aquarius.

Both Mars and Jupiter are invisible for the purposes of the amateur observer. Saturn is well placed for observation, rising on the 1st at 3h. 17m. P.M., and setting at 5h. 3m. A.M., with a northern declination of 9° $10\frac{1}{2}'$, and an apparent equatorial diameter of $19\frac{1}{4}''$ (the major axis of the ring system being $44\frac{1}{4}''$, and the minor $3\frac{3}{4}''$). On the 30th he rises at 1h. 24m. P.M., and sets at 3h. 14m. A.M., with a northern declination of 9° 37′, and an apparent equatorial diameter of $18\frac{1}{2}''$ (the major axis of the ring system being $42\frac{1}{2}''$, and the minor 4·0″). Shortly before 8 P.M. on the 3rd Titan is 17″ south of the planet; and on the evening of the 5th Iapetus will be about 45″ *n* a little *p* Saturn. Early on the evening of the 17th Titan will be seen about 20″ south of Saturn, and on the 22nd and 23rd Iapetus is near its western elongation, and at its brightest. Shortly before Saturn sets on the 30th a 9·5 magnitude star will be seen about 70″ north of the planet. During April Saturn describes a short retrograde path in Leo, but he does not approach any naked-eye star. Uranus is an evening star, rising on the 1st at 8h. 5m. P.M., with an apparent diameter of $3\frac{3}{4}''$, and a southern declination of 11° 0′. On the 30th he rises at 6h. 4m. P.M., with a southern declination of 10° 33′. He describes a short retrograde path to the E.N.E. of 86 Virginis. He is in opposition on the 19th, when he is about $1{,}623\frac{1}{2}$ millions of miles distant from the earth. A map of his path up to the beginning of September will be found in the *English Mechanic* for February 6th, 1891. Neptune is, for all practical purposes, invisible.

Shooting stars are fairly plentiful in April, the most marked shower being that of the Lyrids, with a radiant point in 18h. 0m. R.A. and +33° decl. The radiant point rises on the nights of the 19th and 20th, when the maximum occurs, at 6h. 27m. P.M., and souths at 4h. 8m. A.M.

The moon enters her last quarter at 6h. 30m. A.M. on the 2nd; is new at 8h. 57m. P.M. on the 8th; enters her first quarter at 1h. 40m. A.M. on the 16th; and is full at 5h. 5m. A.M. on the 23rd. She is in perigee at 10h. A.M. on the 7th (distance from the earth 223,850 miles), and in apogee at 11h. 30m. A.M. on the 19th (distance from the earth 251,920 miles). The greatest western libration is at 4h. 54m. A.M. on the 13th, and the greatest eastern at 5h. 44m. P.M. on the 27th.

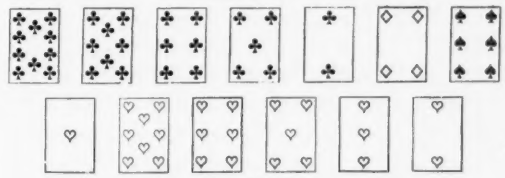
Whist Column.

By W. Montagu Gattie, B.A.Oxon.

The Management of Trumps.

WE believe it was the late James Clay who once facetiously remarked that there were twenty thousand young men going about in rags in America because they would not lead trumps from five to an honour. There are, nevertheless, many cases in which it is desirable to play a waiting game, even though favoured by fortune with great strength in trumps. A curious instance of the success of Fabian tactics is furnished by Hand No. 16 (Knowledge for December last), in which the original leader persistently avoids leading trumps, although holding six to two honours. Such cases are for the most part peculiar, and scarcely admit of generalisation; but perhaps it may safely be laid down that, when the leader's score is 4. he should almost always hesitate to open trumps unless he holds winning cards in the plain suits. A typical case is that in which the hand contains, besides the trumps, *numerical strength only* in one of the plain suits, so that two or even three rounds will probably be required in order to establish it. The advantage, under such circumstances, of opening the plain suit in the first instance, is well illustrated by the following hand, for which we are indebted to Mr. F. S. Hughes:—

Hand No. 19.



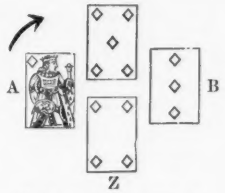
Z's Hand.

Score—AB, 2; YZ, 4.

Z turns up the six of hearts.

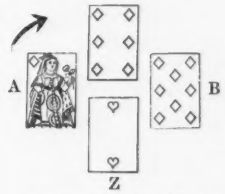
Note.—A and B are partners against Y and Z. A has the first lead; Z is the dealer. The card of the leader to each trick is indicated by an arrow.

Trick 1.



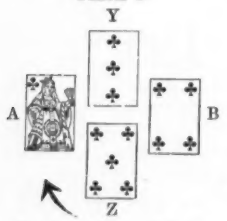
Tricks—AB, 1; YZ, 0.

Trick 2.



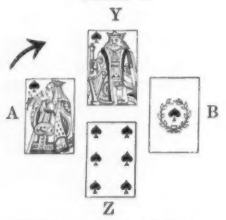
Tricks—AB, 1; YZ, 1.

Trick 3.



Tricks—AB, 2; YZ, 1.

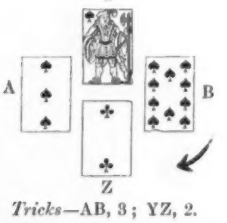
Trick 4.



Tricks—AB, 3; YZ, 1.

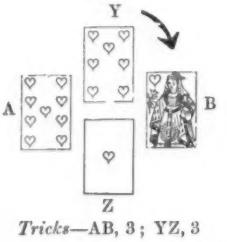
Note.—*Trick* 3.—YZ being at the score of 4, Z determines not to open trumps, and leads his fourth-best club.

Trick 5.



Tricks—AB, 3; YZ, 2.

Trick 6.

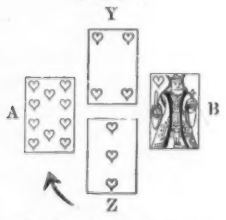


Tricks—AB, 3; YZ, 3

Note.—*Trick* 5.—Z's discard shows five clubs originally, and enables his partner to count his hand.

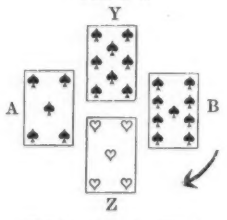
Trick 6.—The four of trumps is now marked in Y's hand, and the three best trumps clearly lie between A and B.

Trick 7.



Tricks—AB, 4; YZ, 3.

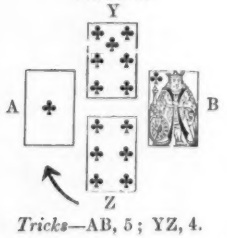
Trick 8.



Tricks—AB, 4; YZ, 4.

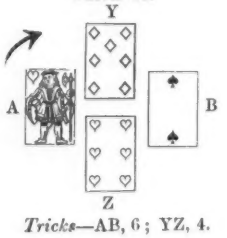
Note.—*Trick* 7.—Z therefore continues the trumps; for, if the adverse trumps are all in one hand, AB must win the game in any case, since they will make three tricks in trumps, and one, at least, in clubs. Accordingly, Z plays on the assumption that the adverse trumps are divided. As the cards happen to lie, he would win the game equally by continuing the club suit; but this would be dangerous, as AB might be enabled to make their trumps separately.

Trick 9.



Tricks—AB, 5; YZ, 4.

Trick 10.



Tricks—AB, 6; YZ, 4.

Tricks 11 to 13.—A leads ace of diamonds, on which Z plays his last trump, and YZ then make two tricks in clubs.

YZ Score the Odd Trick and win the Game.

A's Hand	B's Hand.
H.—Kn, 10, 9.	H.—Kg, Qn.
S.—Qn, 5, 3.	S.—Ace, 10, 9, 7, 4, 2.
D.—Ace, Kg, Qn, 10, 2.	D.—Kn, 8, 3.
C.—Ace, Qn.	C.—Kg, 4.
Y's Hand.	**Z's Hand.**
H.—7, 4.	H.—Ace, 8, 6, 5, 3, 2.
S.—Kg, Kn, 8.	S.—6.
D.—9, 7, 6, 5.	D.—4.
C.—Kn, 9, 7, 3.	C.—10, 8, 6, 5, 2.

Remarks.—*Trick* 2.—If Z intended to lead trumps, he would trump with the five and lead the three; but for the moment he is not anxious to expose his strength.

Trick 3.—If Z leads a trump, AB make at least the odd trick. B wins with the queen, and returns the knave of diamonds. If Z ruffs and continues with the ace of trumps and then a club, A wins with the queen of clubs, and leads the knave of trumps and then the ten of diamonds; if Z ruffs and opens clubs at once, A wins with the queen, and leads the ten of diamonds and afterwards (however Z plays) the ace of diamonds; and, if Z discards his spade on trick 4, B leads the ace of spades, and Z cannot save the game. To return to the actual game, we may observe that those players who adopt the "plain-suit echo" would, in Y's place, play the seven of clubs instead of the three.

Trick 4.—Mr. Hughes remarks that "A leads a spade, and not a diamond, as he does not know whether Z is strong or weak in trumps." We think, nevertheless, that, as A has command of the clubs and some protection in spades, and as YZ are four up and Z is ruffing diamonds, the correct lead is the knave of hearts. This, however, would not save the game unless YZ played badly.

Trick 6.—Y counts three clubs and five trumps remaining in his partner's hand, and therefore leads a trump.

Trick 9.—The beginner should note that even at this point Z would lose the game by continuing the trumps instead of clearing his clubs.

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